Levington Research Station

1961

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LEVINGTON
RESEARCH STATION
1961

Levington
Ipswich
Suffolk *Ipswich 76911*

FISONS FERTILIZERS LIMITED

FOREWORD

LEVINGTON RESEARCH STATION was established in 1957 by Fisons Limited to carry out research to the highest standards in the wide range of sciences and technologies concerned with the provision and use of nutrients for plant growth.

The correlated research programmes are designed to enable the Company to manufacture the most efficient products at the lowest cost and to support these with sound advice on their most economic use. To fulfil this design there are fundamental studies in physical and chemical sciences as well as manufacturing investigations up to the stage of works production, and along with these are basic studies and field investigations on crop nutrition and soil characteristics. Publication of results from these fundamental and applied studies will make a valuable contribution to both scientific and agricultural knowledge.

This book outlines the work that is being carried out by the Levington organization and gives some of the results that have been achieved so far. Although the reader will appreciate the allocation of endeavour implicit in the staff list, emphasis in this book has been placed on those facilities and programmes which are particularly informative on the agronomic interests of the major groups of visitors to Levington and North Wyke.

J. A. STORROW
Director

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LEVINGTON RESEARCH STATION

Director

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Deputy Director

J. G. Hunter, B.Sc., Ph.D.(Glas.), F.R.I.C.

DEPARTMENT OF CHEMISTRY

Head of Department — J. R. Arthur, M.A., B.Sc.(Oxon.), Ph.D.(Lond.), F.R.I.C.

Co-ordination

Chief Chemist — T. P. Dee, B.Sc.(Lond.), F.R.I.C., M.I.Chem.E.

Basic Research Group

Chief Physical Chemist — E. J. Smith, B.Sc.(Lond.), Ph.D.(Dunelm.), A.R.I.C.

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Senior Chemist — F. W. Bennett, B.A., Ph.D.(Cantab.)

Chemists — D. C. Harper, B.Sc., Ph.D.(Lond.)
M. E. U. Taylor, B.Sc., Ph.D.(Lond.), A.R.I.C.
K. F. J. Thatcher, B.Sc., Ph.D.(Lond.)
* * * *

Fundamental Research Section 2

Senior Chemist — K. S. Barclay, B.Sc., Ph.D.(Birm.)

Chemists — J. M. Crewe, B.A.(Oxon.)
P. Doran, B.Sc.(Hull)
R. F. Enefer, B.Sc.(Nott.)
P. S. Smith, B.Sc.(Lond.)
G. D. Woodard, B.Sc.(Lond.)

Physicist — R. V. Coates, B.Sc., Ph.D.(Brist.), A.Inst.P.

Analytical Section

Senior Chemist — W. C. Hanson, A.R.I.C.

Chemists — I. Johnston, A.R.I.C.
D. J. Lloyd
J. W. McMillan, B.Sc.(Birm.), A.R.I.C.
W. K. Thompson, A.R.I.C.

Process Research Group

Chief Chemist — T. P. Dee, B.Sc.(Lond.), F.R.I.C., M.I.Chem.E.

Manufacturing Laboratory Section

Senior Chemist — R. J. Nunn, B.Sc.(Lond.), A.R.I.C.

Chemists — J. K. Bradley, M.Sc.(Lond.), A.R.I.C.
H. F. Godson, B.Sc.(Edin.), A.R.I.C.
R. E. Jewell, M.Sc.(Lond.), A.R.I.C.
* * * *

* * * * Appointments to be made in the Station

Chemical Engineering Section

Chief Chemical Engineer	W. F. Sheldrick, B.Sc., M.Sc.(Dunelm.), A.M.I.Chem.E.
Senior Chemist	G. G. Brown, B.Sc.(Lond.)
Chemical Engineers	G. T. Dee, B.Sc.(Eng.) (Lond.)
	S. M. Janikowski, B.Sc.(Eng.) (Lond.)
Chemists	D. H. Booth, B.Sc.(Hull), A.R.I.C.
	G. N. Quinton, B.Sc.(Lond.)
	N. Robinson, B.Sc.(Lond.)
	R. G. Wilson, B.Sc.(Lond.)

* * * *

BRAMFORD DEVELOPMENT STATION

Manager — S. J. Porter, B.Sc.(Manch.), M.S.(Pittsburgh), F.R.I.C., M.I.Chem.E.

Fundamental Section

Chief Chemical Engineer	G. A. Turner, B.Sc., Dip.Chem.Eng.(Lond.), Ph.D.(Manch.), A.M.I.Chem.E.
Chemical Engineers	R. W. Silvester, B.Sc.(Lond.), A.M.I.Chem.E.

* * * *

Process Development Section

Senior Chemical Engineer	C. N. Silvester, B.Sc.(Sheff.), A.M.I.Chem.E.
Chemical Engineers	R. M. Dannatt, B.Sc.(Wales), B.A.(Cantab.), A.R.I.C., A.M.I.Chem.E.
	W. G. Masson, B.Sc.(Birm.)
	W. A. White
Chemist	J. M. Clarke, B.Sc.(Birm.)

Special Fertilizer Section

Senior Experimental Officer — R. W. Palmer

Laboratory Section

Senior Chemist — J. W. Fox, B.Sc.(Lond.), A.R.I.C.

Package Development Section

Chemist — D. B. Ratcliffe, A.R.I.C.

Engineering Section

Mechanical Engineer — * * * *

DEPARTMENT OF SOIL SCIENCE

Head of Department — J. G. Hunter, B.Sc., Ph.D.(Glas.), F.R.I.C.

Agronomic Group

Agriculture Section

Chief Agriculturist	J. A. Birch, B.Sc.(Leeds), N.D.D.
Senior Agriculturists	D. F. Constantine, M.A.(Cantab.)
	J. V. Harbord, M.A.(Cantab.), A.I.C.T.A.(Trin.)
	J. D. Whitear, M.Sc., Dip.Agr.(Reading), M.A.(Cantab.)

Senior Field Officers	A. M. Ainsley, N.D.A. F. W. Dunnett, N.D.A., N.D.D.
Agricultural Economist	F. J. Orton, B.Sc., Dip.Agr.(Leeds), B.Litt.(Oxon.)
Economics Officer	C. E. McCarter
Agricultural Advisers	J. M. Coull, B.Sc.(Nott.) J. D. Edward, C.D.A. I. R. English, M.C., M.A.(Cantab.) W. K. Letheren, N.D.A. W. A. G. Mason, B.Sc.(Reading)
Farm Manager (Levington)	J. T. Pemberton, B.A.(Cantab.)

Grassland Research Section (North Wyke Experimental Station)

Chief Grassland Officer	P. G. Shaw, B.Sc.(Reading)
Grassland Research Officers	J. S. Brockman, B.Sc.(Agr.) (Lond.), Ph.D.(Dunelm.) Miss K. M. Wolton, M.Sc.(Agr.) (Lond.)
Grassland Experimental Officer	P. E. J. Gwynn, N.D.D.
Field Officer	D. W. T. Brough, B.A.(Cantab.)
Field Experimental Officer	* * * *
Farm Manager (North Wyke)	R. H. Pelly, B.A.(Cantab.)

Grassland Research Consultant: Professor J. D. Ivins (University of Nottingham)

Horticulture Section

Chief Horticulturist	O. B. Orchard
Senior Horticulturist	P. S. Atkins, B.Sc.(Nott.)
Horticultural Experimental Officers	D. H. Riley, B.Sc.(Leeds) S. B. Tree, N.D.H.
Horticultural Advisers	J. C. Bush, B.Sc.(Reading) H. R. Dally, N.D.H. G. A. V. Ellis, N.D.H. C. Evans, B.Sc.(Reading) C. P. Quarrell, B.Sc.(Reading), N.D.H. M. J. Rhodes, N.D.H.
Turf Adviser	D. J. Allott, B.Sc.(Lond.)

Field Experiment Section	
Chief Field Experimental Officer	J. R. Devine, B.Sc.(Agr.) (Glas.), N.D.A.
Senior Field Experimental Officer	M. R. J. Holmes, M.A., Dip.Agr.(Cantab.)
Field Experimental Officers	R. S. Adamson, B.Sc.(Agr.), Ph.D.(Dunelm.), A.R.I.C.
	J. Davison, B.Sc.(Agr.) (Dunelm.), Ph.D.(Nott.)
	R. L. Morris, B.Sc.(Hort.) (Nott.), D.T.A.(Trin.)
	D. E. J. Thomas, B.Sc.(Agr.) (Wales), S.D.A., S.D.D., N.D.D.
Statistics Section	
Senior Statistician	J. C. Dickins, M.A., Dip.Math.Stats.(Cantab.)
Statistician	P. Hallam, B.A., Dip.Agr.Sci.(Cantab.)
Analytical Section	
Senior Soil Analyst	J. Hislop
Senior Soil Analyst	E. E. Jusa, D.Phil.(Vienna)

Fundamental Group

Soil Chemistry Section	
Chief Soil Chemist	S. Larsen, B.Sc.(Agr.), Lic.Agr.(Copenhagen)
Soil Chemists	I. J. Cooke, B.Sc., Ph.D.(Leeds), A.R.I.C.
	M. N. Court, B.Sc., Ph.D.(Brist.)
	A. V. Flegmann, Dip.Agr.(Budapest)
	D. Gunary, B.Sc.(Nott.)
	D. J. Parton, B.Sc.(Wales)
	C. D. Sutton, B.Sc., Ph.D.(Nott.)
Biochemistry Section	
Senior Biochemist	F. E. G. Harrap, B.Sc., Ph.D.(Lond.), D.I.C.
Biology Section	
Senior Biologist	R. C. Stephen, B.Sc., Ph.D.(Aberdeen)
Biologist	J. S. Waid, B.Sc.(Lond.), B.Sc., D.Phil.(Oxon.)
Plant Physiology Section	
Senior Plant Physiologist	P. C. Owen, B.Sc.(Wales), Ph.D.(Lond.)

ADMINISTRATION

Accountant-Secretary	C. Hancock, A.C.W.A.
Accountant	W. H. Fox, A.A.C.C.A.
Assistant Accountant	N. Coe, A.C.W.A.
Librarian	T. Cawley, B.A.(Sheff.), A.L.A.
Administrative Officer	D. W. Duke-Williams, M.A.(Cantab.)
Maintenance Superintendent	H. G. Horne

Assisting the Director:	
Chief Chemical Engineer	K. A. Sherwin, B.Sc.(Eng.) (Lond.), D.I.C., A.M.I.Mech.E., M.I.Chem.E.

INTRODUCTION

THE LEVINGTON RESEARCH ORGANIZATION consists of the Central Laboratories at Levington, together with two associated farms and a horticultural unit, Bramford Development Station near Ipswich, and North Wyke Experimental Station in Devon. The administrative staff at Levington provide the services at these sites including accounting, library, and instrument and engineering workshops which are necessary in such a scientific research group of this diverse nature.

The work of the organization is almost equally divided between studies associated with production of fertilizers (Chemistry Department and Bramford Development Station) and investigations on fertilizer usage (Soil Science Department).

The Department of Chemistry studies the fundamental physical and chemical properties of raw materials and end-products, and the kinetics of conversion reactions. It also investigates new and improved processes for producing plant nutrients in forms which have suitable properties in manufacture, handling and use. Larger scale process investigations are transferred for appraisal to the Bramford Development Station, where suitable control laboratories, workshops and more extensive chemical engineering facilities are available. This Station also studies plant modification and operation problems in collaboration with the manufacturing works of Fisons Fertilizers Limited.

The Department of Soil Science deals with soil and agronomic problems associated with the use of fertilizers. The fundamental studies and experimental investigations of materials in the Levington laboratories, pot trials and field experiments are supplemented by extensive trials throughout the country, controlled by the central staff and conducted by provincial officers on land of co-operating farmers and growers. The grassland research section of the Department is at North Wyke.

The Levington organization employs about one hundred and ten graduates and three hundred and fifty non-graduate staff and wage-earners.

Department of Chemistry

Two main types of problem are studied in the Department:

(a) complete and partial manufacturing processes on the bench and semi-technical scale,

(b) supporting work on the physical properties of individual and mixed fertilizers which influence manufacturing procedures, handling and storage properties; also on the reactions which take place when the individual fertilizers are mixed in the presence of water.

The Department is composed of two main Groups whose activities are largely defined by the division of the work according to the main two problems stated above. These Groups are the Basic Research Group and the Process Research Group.

Throughout the Department, extensive use is made of modern physico-chemical techniques to provide detailed assessment of the solid and liquid systems handled in the research work. There is a marked trend towards equipment based essentially on physical principles. Examples of apparatus in use are as follows:

(a) X-ray diffraction apparatus with photographic and Geiger-counter attachments,

(b) electron and polarization microscopy,

(c) isotopic counting equipment for a variety of tracer applications,

(d) infra-red, visible, and ultra-violet spectroscopy for analytical purposes,

(e) gas and liquid chromatography for separation and analytical purposes.

Basic Research Group

This is divided into three Sections dealing with physico-chemical research and analytical problems.

Fundamental Research Section I. Studies are in progress on the fundamentals of granulation, the drying characteristics of granular materials, the equilibrium properties of fertilizer/moisture systems, and reaction mechanism studies in the acidulation of rock phosphate.

The mechanism of granulation of mixed fertilizers is a matter of great complexity and it is found useful to isolate certain parts of the over-all process and study them individually. Attempted extrapolation of some results from small-scale equipment to production scale must be handled cautiously. The drying part of the process considered as a kinetic problem can, however, be studied usefully with small numbers or even individual granules. The form of the drying curve gives information about the rate controlling features of the process, and hence the relative importance of chemical and physical make-up of the mixed fertilizer.

Department of Chemistry

The tendency of fertilizers to pick up moisture is a primary criterion in their satisfactory use, and measurements of the conditions of temperature and atmospheric humidity below which this will not occur are very important for all compounds marketed by the Company, both at home and in significantly different climates abroad. This 'critical humidity' work has disclosed a number of complicating features associated with the effects of moisture content of the fertilizer and its age.

The reactions of mineral acids with rock phosphates are being studied to attempt to identify some of the individual elementary chemical steps in the over-all process and to pinpoint primary differences in over-all properties for the different acids and phosphate rocks of interest. The reactions are examples of heterogeneous solid/liquid changes with reaction products having a primary influence on acid attack and with complications arising from 'chemical' and 'diffusional' resistances of comparable orders.

Fundamental Research Section II. Present studies include kinetic studies of some thermal reactions in mixed fertilizers, the diffraction of X-rays by inorganic salts, the thermal analysis of fertilizers, and the adsorption of vapours by solid surfaces.

When ammonium nitrate is mixed with other plant food carriers, undesirable chemical reactions may take place which present serious problems in the processing and storage of these materials. The nature of these reactions has been elucidated and means for their avoidance discovered. With the co-operation of the Development Station and Production Department, these results have been used with effect in the Company's manufacturing operations.

Much has been learnt about the crystallographic constitution of mixed fertilizers by the X-ray technique. This information is important in disclosing significant steps in granulation processes and making possible correlations between crystallographic make-up and storage quality.

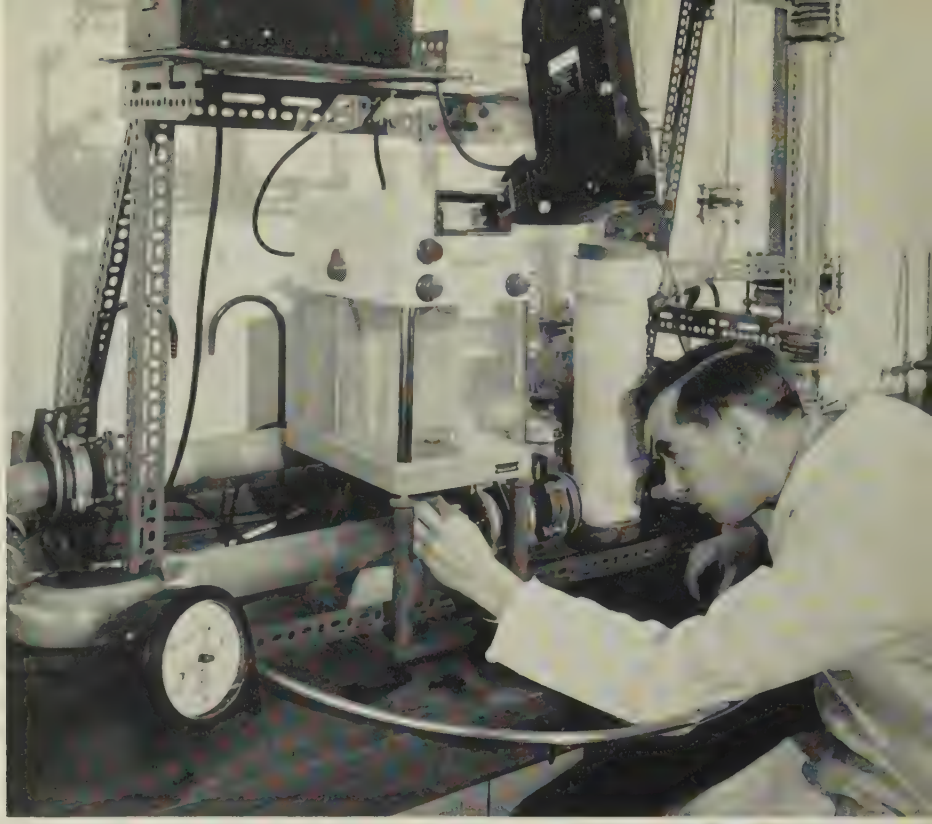
The thermal analysis technique, which depends upon a specific energy change undergone by a component of a system over a restricted temperature range, provides the possibility of a physical analysis supplementary to X-rays. Fertilizer components, e.g. ammonium nitrate, potassium nitrate and ammonium chloride, exist in more than one crystal form at different temperatures: the actual energy changes occurring in transition from one form to another may be used for analytical purposes.

Analytical Section. This Section is responsible for all chemical analytical work coming from the Departments of Soil Science and Chemistry dealing with fertilizers and with fertilizers incorporating additives such as pesticides. The specific determination of organic pesticide concentration in the presence of fertilizer environment creates numerous analytical difficulties, but considerable progress has been made applying chromatographic and infra-red spectrographic techniques. A balance is maintained between routine analysis and development of new analytical methods.

Mention may be made of the success achieved in devising a method of determining

The main building contains laboratories, library, conference rooms and offices.

A general view of an Analytical Laboratory of the Chemistry Department.



paratus used in the study drying characteristics of anular materials.

emical engineering studies pilot plant scale are carried t at Bramford Develop- ent Station.

trichloracetate in NPK fertilizers. The free acid, together with its main contaminant dichloracetic acid, is extracted from the fertilizer, chromatographed and the individual acids titrated with sodium methylate (Johnston, I., 1960. *J. Sci. Fd Agric.*, **11**, 695–700).

A large effort is being devoted to understanding the state of residual water in granular fertilizers, since the economic production of concentrated compounds is considerably dependent on this. The requirement for manufacturing control is high accuracy at the 0·3 per cent level in mixtures showing a variety of binding tendencies for the water.

Process Research Group

This is divided into two Sections, one of which is mainly concerned with laboratory scale research and the other with semi-technical scale work in the Process Laboratory.

Manufacturing Laboratory Section. Investigations are carried out with the object of continually improving the range of fertilizers marketed. The work is done in close collaboration with the Production Department, the Soil Science Department and the Basic Research Group. Studies of portions of over-all manufacturing processes are made with the particular objective of predicting large-scale behaviour. The assessment of storage characteristics forms an important part of the work and an excellent laboratory test method has been developed for this purpose. The original version of the apparatus (Whynes, A. L. and Dee, T. P., 1957. *J. Sci. Fd Agric.*, **8**, 577–591), has since been improved and extended in scope: the original compression apparatus being replaced by an apparatus designed and built at Levington, in which compressed air is used to apply the shear stress to the caked specimen. Storage experiments are now carried out at 35° C. and present facilities enable 1,120 specimens to be tested simultaneously.

Chemical Engineering Section. This is composed of a team of chemical engineers and chemists who are mainly concerned with the design and operation of semi-technical plant used to investigate new and improved manufacturing processes: the Section is self-supporting for its analytical control work.

Considerable attention is given to the principles of the manufacture of phosphoric acid, especially by the wet process. This material is perhaps the most vital of all intermediates in the manufacture of concentrated fertilizers. Reaction kinetics, reaction engineering and basic studies of crystallization and filtration are applied with a view to obtaining maximum extractive efficiency and high throughput from plant of given dimensions. There has been fruitful co-operation with the Development Station and Production Department.

In both these sections, a number of fertilizers are prepared for field experiments and pot trials by the Soil Science Department and the effort required in providing this service is increasing with each season's application.

Bramford Development Station

This Station is primarily a site for chemical engineering investigations, the main areas being pilot plant buildings with associated laboratories, offices and workshops. The graduate staff are supported by teams of process operators and engineering craftsmen providing the abilities for designing, erecting and operating pilot plants with their associated control systems and laboratory apparatus of specialized kinds.

The Station is concerned with establishing new or modified techniques for the production of fertilizers. The studies on relevant operations form individual programmes which may well spring from the knowledge and interests of the staff, many of whom have had experience in the factories. Similar types of problems may be raised by the technical staff of the Production Department. The work requires close collaboration with that Department, and may also involve the Development Station staff in full-scale trials on producing units or in providing commissioning teams for new processes. Throughout their work the staff maintain close collaboration with the Chemistry Department, particularly in developments stemming from new processes and operations studied in that Department. The major studies thus range from the re-appraisal of hitherto established processes for the manufacture and handling of nutrient source materials to the investigation of novel procedures, chemical processes, physical operations and automatic control. Important subsidiary studies are concerned with improving packages for agricultural products.

Since the formation of the Development Station, important contributions have been made to the improvement of the Company's processes. The first production of small quantities of 40 range fertilizers containing ammonium nitrate was carried out at this Station and experimental teams from the Station assisted in the establishment of these processes in the Company's factories. There has been continued interest in the manufacture of phosphoric acid, and model studies at the Development Station have been carried out in close collaboration with kinetic studies in the Chemistry Department, leading together to greater understanding of this process.

Fundamental Section. This Section is concerned with basic research in fields of interest in connection with the processing of the Company's products. Experimental techniques of interest are those having a bearing on plant control, through transient response studies, continuous sampling, and measurement and analysis of plant streams in production processes. The link between studies in this Section and production processes will be by means of the Process Development Section at Bramford, either directly or through the Process Research Group of the Department of Chemistry.

Process Development Section. The main process pilot plant activities are controlled and studied by this Section, e.g. the translation of physico-chemical kinetic studies from the Chemistry Department into preferred operating conditions, to guide manufacturing units, by the provision and study of appropriate model plants. The staff maintain a range of pilot facilities covering the normal manufacturing processes of the Company, as well as those for studying novel methods.

Special Fertilizer Section. This Section has two main functions. The first is the preparation of special fertilizers for the agronomic work of the Soil Science Department. These may differ materially from current products, and in any case close analytical tolerances and size specifications may be called for, as well as additives not present in conventional formulations. For this purpose, the Section has access to the pilot granulating and drying plants with capacities up to 2 tons per hour of product. The Section also studies in very small-scale experiments the more important variables affecting granulation. The equipment used for this purpose is also used for the first assessment of the behaviour of some new product formulations so that initial operating conditions for larger scale work either on pilot plant or full-scale plants can be recommended.

Laboratory Section. This Section provides the control analyses for all activities at the Development Station, and in addition work is done on methods of analysis and miscellaneous problems associated with the pilot plants. Photographic work required by the Development Station is carried out by the staff of the Laboratory.

Engineering Section. The provision and maintenance of various pilot plants and services require extensive engineering facilities. Whenever possible, the equipment to be used at the Development Station is made by this Section and all plant is maintained and modified according to the process needs.

Package Development Section. This Section is concerned with the improvement of packages for agricultural fertilizers and controls both small-scale physical testing of sack materials, usually paper, and full-scale experimental work with filled packages. Chemical studies concern the development of acid-resistant coating agents for use with paper sacks and degradation of paper when in contact with reactive fertilizers.

Department of Soil Science

The Soil Science research programme is designed to advance knowledge of soil and agronomic problems, especially in relation to fertilizer usage. The long-term study of fundamental principles is important, but many problems of more immediate concern are also considered. Laboratory studies and pot and field investigations are closely integrated.

Agronomic Group

This Group is concerned with applied studies which are principally field and pot investigations related to fertilizer usage. Fertilizer recommendations made by the Company are based on the results of field experiments carried out by Levington and other research organizations with which close liaison is maintained.

Investigations examine the relative agronomic efficiency of nutrient sources derived from different raw materials and methods of manufacture and are concerned also with the time and rate of application of nutrient materials as well as associated subjects, including minor element significance and the use of insecticides and herbicides incorporated in fertilizers.

The Group consists of four Sections directly concerned with these applied studies and two Sections which primarily have service responsibilities to the Department as a whole.

Agriculture Section. The two farms at Levington are the responsibility of this Section and their prime requirement is to provide facilities for fertilizer experiments on agricultural crops. Farming as an enterprise often has to be secondary.

The land at Levington is predominantly light with low rainfall, especially in the spring. This contrasts with the Grassland Research Section farm at North Wyke which is a heavy-soil farm in a wet area. These soil and climatic facilities are substantially expanded by eight Agricultural Advisory and Field Officers, who carry out the provincial field experimental programme, assisted by Recorders. In this way the variations in soil, climate and farming systems that occur in British agriculture are adequately covered.

These provincial officers are also available as specialists working in co-operation with the Technical Advisory Service for advising farmers and can refer field problems that require special research investigation to Levington.

Grassland output can only be adequately measured by grazing animals and, unless new techniques are developed which will make expansion of animal experiments

from research stations to commercial farms possible, it will never be feasible to obtain results widely applicable on farms. Following three years' experience on pilot schemes, a grassland recording scheme was carried out during 1960 in conjunction with the Technical Advisory Service. Forty commercial farms in the western half of the country were surveyed and the scheme is to be extended in 1961 to cover dairy farms in all the main milk-producing areas.

The 'utilized starch equivalent' (U.S.E.) method of grass recording has been chosen in order to take into account the wide variations in feeding practices on farms. This makes possible conversions into money terms necessary for economic assessments of the results.

The information obtained will be complementary to, but not a substitute for, field experiments. The technique has the additional advantage that the results are directly applicable to the commercial farm.

Grassland Research Section. This Section, located at North Wyke Experimental Station in Devon, is responsible for the research programme investigating the effect of fertilizer usage on grassland. The grassland research section co-ordinates the whole grassland programme which is carried out at Levington, the provinces and at North Wyke. The Section is also responsible for the management of the farm.

The fertilizer responses of grassland under various types of management are measured and pasture quality differences are examined in terms of chemical and botanical contents, digestibility and milk production. The major part of this programme is carried out at North Wyke, where farming policy is largely determined by experimental requirements.

Horticulture Section. The sixty-acre Horticultural Unit at Levington provides horticultural crops for research purposes. In this, the Section collaborates with the Field Experimental staff, thus ensuring that experimentally valid results are related to crops produced to the highest standards of cultivation. Projects on fertilizers, insecticides, herbicides and fungicides are all included in the research programme.

Nine glasshouses, constructed and operated according to normal commercial practice, cover half an acre. These houses, all under experimentation, are planted with tomatoes, cucumbers and carnations. Twenty-eight acres of apples and pears are grown on the delayed open-centre method and most of this area will not be under experiments until the trees are fully established. Experiments on vegetables occupy about two acres each year. Five acres of fine turf are available and investigations are proceeding on a wide variety of subjects. A two-acre unit planted with an extensive

variety of flowers, vegetables, fruit, shrubs and trees provide facilities for research mainly for products sold in the amateur market.

The Section has a complement of eleven, comprising two Experimental Officers, a Turf Adviser and general Horticultural Advisers who are stationed at Levington and in the provinces.

Field Experiment Section. The Section is concerned in planning and co-ordinating the Levington Field Experiment programme investigating the field behaviour of nutrient sources and of fertilizer materials produced by new processes and examining problems arising in fertilizer usage on agricultural and horticultural crops. The Section is responsible for the conduct of experiments on agricultural and horticultural crops at Levington and collaborates with the Agriculture Section in those sited in East Anglia and south-eastern England. The facilities at Levington enable more detailed experiments to be carried out on arable crops than is possible in provincial experiments and allow the controlled use of the grazing animal in grassland experiments.

The development and improvement of techniques and machines used in all the field experiments are the responsibility of the Section, ensuring a high over-all standard of experimentation.

The Pot Trials Unit consists of a preparation building, a covered cage, a Dutch light structure and six Hartley glasshouses where heat and artificial illumination are available. These facilities are available for the preliminary study of nutrient sources and to supplement information obtained from field experiments as well as providing a service to the fundamental research sections.

Statistics Section. Field and pot trials are designed and a computing service for the statistical reduction and analysis of data is provided. Experimental techniques are investigated statistically and advice is given on problems of a more general mathematical nature.

Analytical Section. Soil and crop samples are taken through routine analysis at a rate of 60,000 samples annually. Of these samples 31,000 form part of the advisory service to farmers and growers, the remainder being derived from research investigations. Considerable attention is being devoted to the application of mechanization and automation techniques to facilitate these analyses. Laboratory procedures are also being examined and new methods will be introduced where they show advantages over the existing ones.

Basic Research Group

This Group is concerned with fundamental studies on the relationship between soil, nutrients and crop growth.

The main field of research is soil phosphorus, the interactions between applied phosphorus and the soil, and the relationship of these to crop production. The study requires co-ordinated research from the four Sections of this Group, though each Section has its own special approach.

Other topics studied include the loss of nitrogen as gaseous ammonia from the soil after application of nitrogenous fertilizers, the effect of environmental factors, particularly soil water, on plant growth, and the relationship between plant nutrition and disease incidence.

Soil Chemistry Section. Soil phosphorus systems are extremely complex and in order to simplify their study they are being approached in this Section from three complementary aspects which, when integrated, will provide a more complete understanding of the whole. These aspects comprise a capacity factor, an intensity factor, and a kinetic factor. As comparative material for use in these studies, twenty-three British soils were enriched in 1957 with 500 lb. and 1,000 lb. water-soluble P_2O_5 per acre; these also allow the fate of applied phosphate to be followed on the above lines.

In considering the capacity factor, a suitable method for the determination of total soil phosphorus has been developed and various techniques are being used to divide this into its components. The labile soil phosphorus is measured by isotopic dilution, either in pot experiments (L values), or laboratory experiments (E values). In past experiments the importance of technique details in L-value estimations has been examined and, in addition, the L values of the enriched soils have been measured for three seasons; from average figures it appears that some of the applied phosphate has remained labile for three seasons. From the relative mean content of labile phosphorus in these soils after soluble-phosphate application in 1957, various proportions of the applied phosphate were found to have remained labile. For 500 lb per acre applied P_2O_5, relative figures for the year of application and for one and two years after application were 100, 56 and 37, and for 1,000 lb per acre the figures were 100, 77, 48.

A technique for E-value measurement has been developed and a comparison has been made with L values on a number of soils. Differences between the two values have been observed; the reason for this is under investigation. Isotopic dilution techniques have been used in conjunction with measurement of total inorganic phosphorus; an extension of this technique will be used to categorize inorganic phosphate into various groups. A study is also being made of chemical interactions between inorganic phosphate and soil organic matter.

Phosphate potential measurements (the intensity factor) have been made on the enriched soils and have shown that the phosphate potential was influenced by the level of phosphate enrichment. Soil phosphate solubilities calculated from the potentials have been shown to bear a hitherto unknown relationship to soil pH (Larsen, S. and Court, M. N., 1961. *Nature, Lond.*, **189,** 164–5). The variation of potential with soil/solution ratio has been examined fundamentally and similar relationships found to hold for soluble silicate. The phosphate potentials of some forestry soils have been measured, with particular reference to variations down the soil profiles.

Phosphate reaction rates constitute a kinetic factor and techniques to further this study have been developed based on the principle of isotopic exchange and extraction by means of anion exchange resin. The rate of release of phosphate from the solid phase of a soil to the soil solution has been found to be correlated with the phosphorus uptake from the soil by plants.

A subsidiary investigation is that of nitrogen loss when fertilizers are applied to soils. This is being considered both fundamentally and agronomically.

Biochemistry Section. The decomposition of ryegrass roots in soil and the subsequent changes in soil water-soluble phosphorus level have been the major topics investigated by the Section. The changes in level of water-soluble phosphorus so far observed have been small in relation to the phosphorus added in the roots. Addition of roots to a soil equilibrated with P^{32} gave rise to an increased release of water-soluble P^{32} suggesting that root addition had had some effect on the native soil phosphorus. Changes in soil nitrogen, carbon and organic phosphorus content, and of carbon dioxide production, are being studied in relation to the changes in water-soluble phosphorus level produced as a result of root incorporation.

Chromatographic methods for the determination of the phosphorus compounds in water extracts of soil have been improved (Harrap, F. E. G., 1960. *Analyst*, **85,** 452). Despite the improvements, the existence of any individual water-soluble organic phosphorus compound has not been demonstrated. Because of the difficulties involved in the chromatography of water-soluble phosphorus compounds, a project has been started on the chromatography of soil organic phosphorus, using as extractants sodium EDTA and caustic soda.

Analytical techniques for the determination of biuret and cyanate in soil are under investigation. A further project to determine the distribution of soil and foliar applications of phosphorus in pea plants has been carried out using P^{32}. Some aspects of the potato quality experiments relating to potash nutrition have been published (Harrap, F. E. G., 1960. *J. Sci. Fd Agric.*, **11,** 293–298).

Biology Section. The Section is mainly concerned with the relationship between soil micro-organisms and soil and applied phosphorus and between host nutrition and disease incidence. Research on the former is still in the early development phase but some experimental data have been obtained using established techniques.

Several experiments have examined the effects of adding decomposable organic materials to soil on the response of plants to applied nitrogen and phosphorus. These have shown that plant response and phosphorus uptake are influenced by organic material type and by the time and rate of application both of the organic material and of nitrogen.

Field trials have indicated that a decrease in potato blight disease on the foliage is associated with increase in the rate of both nitrogen and potash application. Susceptibility to blight increases with physiological age which is influenced to some extent by the effects of plant nutrient application on plant development. Nitrogen application, for example, to the seedbed prolonged the flowering period and reduced the effect of blight.

Preliminary results from winter wheat field experiments show that whilst phosphate and potash applications to the seedbed have no effect on the incidence of take-all disease, increase in the rate of applied nitrogen considerably reduced stand losses and gave increased yields as a result. Nitrogen applied in the autumn had little effect, but spring applications considerably reduced the damage. Early applications were more effective than late ones.

An extensive laboratory and pot trial programme designed to evaluate the agronomic efficiency of fertilizer urea as a nitrogen-supplying material has been initiated. Preliminary results indicate that dry matter responses to urea are poorer than from ammonium sulphate or ammonium nitrate. A relationship exists between urea application and soil type in which the adverse effects of urea are more evident on sandy soils and less evident on clay organic soil types.

Plant Physiology Section. The main research topic of the Section is investigation of the interaction between environment and inorganic nutrition in relation to plant growth and nutrient absorption, with particular reference to phosphorus. Experimental work has indicated variation in response to phosphorus at different times of year and particularly under different light conditions, and further work on this is being carried out.

Concurrent with this, other aspects of plant responses to nutrients are being examined, mainly in solution culture. The significance of the early phosphorus response observed in certain crops is under examination. The main interest here is in the fact that this response is sometimes reflected in final yield, but not invariably so,

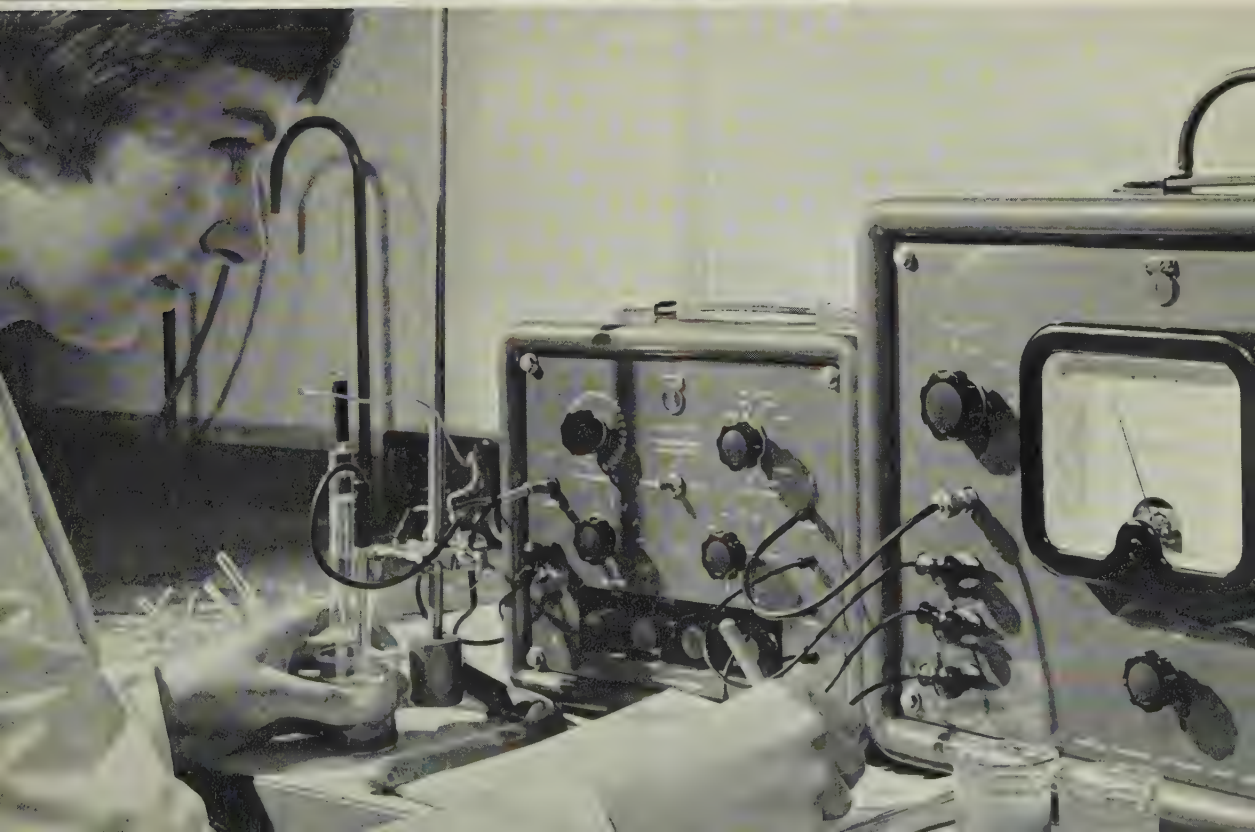
and an attempt will be made to elucidate the conditions governing its persistence. This study will include examination of the relative significance of phosphorus absorption by the plant at different ages, or physiological stages.

Preliminary work has been carried out on the phosphorus requirements of sugar beet under different water regimes in small-plot experiments under a Dutch Light structure, but progress has been limited by difficulties incurred with suitability of the site.

In all the work the main approach has been through the techniques of Growth Analysis, depending either on successive destructive samplings of the crop or on successive estimations of particular attributes, such as leaf area, on the same individual plants throughout their growth.

Automatic counting units used to measure radiation from experimental samples employing radio-active tracers.

pH determinations are made in research studies and in routine soil analysis.



A cereal experiment being harvested at Walk Farm.

The Red Poll herd is used for hypomagnesaemia studies.

Levington Farms

The two farms at Levington are laid out and farmed to provide facilities for fertilizer experiments on farm crops. They occupy three hundred and thirty five acres which formerly would have been described as 'sheep and barley' land. It is predominantly light loam of glacial origin overlying sand and gravel situated on the plateau between the Deben and Orwell estuaries in Suffolk.

The annual rainfall can vary between about fifteen and thirty inches, but long periods of drought are usually prevalent, particularly in the spring. For example, the rainfall in 1959 was 15·7 inches but there was less than six and a half inches between March and September. The rainfall in 1960 was 32·51 inches but little more than one inch fell during the period April and May. The average for the Station over the last six years is 23·34 inches.

Walk Farm and Red House Farm were purchased in October, 1953. During 1954 and 1955 many changes were carried out; rabbit-infested banks between fields were bulldozed out, superfluous fences removed and scrub eliminated. In addition, hedgerows and five shelter belts were planted, some to minimize the risk of wind erosion, and at Red House Farm all fields were refenced. At Walk Farm, where the only buildings were two open cattle yards and a thatched barn, three new buildings were erected to give tractor, implement and workshop accommodation, a fertilizer store, grain drying and storage facilities, and covered cattle yards for winter beef production. In 1956 a further building was completed at Red House Farm to provide a milking parlour and dairy, two covered yards with feeding passage, implement shed and dutch barn storage, all under one roof. Early in 1957 a range of old buildings at this farm was reconstructed to make loose boxes, calf pens, a bull pen, a meal barn and an open yard. There are walled pit silos at both farms.

WALK FARM–235 acres

Owing to the uniformity of soil type, this farm is very suitable for fertilizer experiments and large-scale trials. After two initial cropping years to assess this uniformity, Walk Farm has been developed into five specific areas numbered 11–15. (Red House Farm fields are numbered 1–10.)

Area 11. The fertilizer and cropping policy on this area of over fifty acres is designed to give each year a different experimental area with a controlled nutrient status. This

N
C1
RED CLOVER
C2
RED CLOVER
D
BARLEY
(UNDERSOWN)
11
B
WINTER WHEAT
13
E
ANNUAL EXPERIMENTS
Z
F2
KALE
Y
WINTER WHEAT
F1
A
SUGAR BEET
POTATOES
14
15
X
PEAS
C
W
POTATOES
B
WINTER WHEAT
6-COURSE
ARABLE ROTATION TRIAL
(SEE P.26)
A
D
SUGAR BEET
F
E
KALE
E
D
F
M
12
MAIZE
C
12-COURSE
MIXED FARMING ROTATION TRIAL
(SEE P.26)
L
TO IPSWICH
B
K
BARLEY
KALE
A
J
POTATOES
H
G
LONG TERM AND ROTATION EXPERIMENTS
POTATOES
TO FELIXSTOWE
WALK FARM
Experimental areas 1961
Shelter belts

status is sufficiently low to grow crops that are responsive to fertilizer treatments, as free from disease as possible and where weeds can readily be controlled by mechanical methods. This is required for the critical comparison of different sources of fertilizer produced, for example, from different raw materials or by different methods of manufacture. It is under these conditions that appropriate variation in crop performance can best be detected. At the same time the sources are examined on other land more typical of the normal levels of nutrients used in commercial farming.

The area is cropped on a six-course rotation (one break of which is used for experiments) as follows:

	Crop	Fertilizer	cwt/acre	Remarks
A.	Sugarbeet	Nitrogen (S/A)	4	Experiments 1957
		Nitrate of Potash	2	
B.	Winter Wheat	Farmyard manure	20 tons	Experiments 1958
		Nitrogen (S/A)	5	
C.*	Clover	None	—	Experiments 1959
D.	Barley undersown	Nitrogen (S/A)	1½	Experiments 1960
E.	Annual experiments	Experimental	—	—
F.	1. Potatoes	Nitrate of Potash	3	Experiments 1962
	2. Kale	Nitrogen (S/A)	3	Experiments 1962
		Nitrate of Potash	3	Experiments 1962

C* = C_1 and C_2 (see map page 24).

S/A = Sulphate of Ammonia.

Farmyard manure is applied once in the rotation to ensure that the soil structure does not deteriorate to the detriment of experimental results, and lime, if necessary, is applied on the furrow prior to drilling wheat. The place in the rotation selected for these applications is such that they will cause minimum interference with the experimental nutrient responses.

Nitrogen is applied at rates to ensure full crops except on the potatoes and kale, where the rates are well below the normal uptake by these crops in order to minimize any chance of excess residual nitrogen which would interfere with nitrogen experiments in the succeeding year. Potatoes, sugarbeet and kale have a high potash requirement and a small amount is now given to these crops on these breaks to prevent the crop failure that experience with this soil has shown would otherwise occur.

Levington Farms

Soil analyses and a response trial in the previous year are both used to assess the soil reserves of available plant nutrients for the 'experimental' break in the rotation.

Potatoes and kale are both grown in the crop break of the year preceding experiments, so that when the potato crop is required for experimentation it can follow the kale and so avoid having the same crop for two successive seasons. This rotation, designed for experimental purposes, may be modified as a result of information gained from rotation experiments carried out on Area 12.

Area 12. Part of this area is used for long-term and rotation experiments that are put down for an indefinite period. Part is reserved for future experiments; meanwhile it grows farm crops in the normal way but careful control is maintained on the amount of nutrients applied.

Area 13. This thirty-five acre area is farmed on a four-course arable rotation, and is used for other types of fertilizer experiments on arable crops for which the 'low nutrient' status of Area 11 is unsuitable.

Area 14 and Area 15 – Large Scale Trials. About seventy acres of these two areas are devoted to two large-scale trials consisting of a six-course arable rotation and a twelve-course mixed farming rotation.

The objects of these trials are to determine the most economic compound fertilizer levels under Levington conditions on two rotations representing different farming systems, and to assess the effect of residual value of these fertilizer treatments upon other treatments in subsequent crops.

Some parts of these areas not occupied by the large-scale trials are available for annual experiments but otherwise they are farmed in a normal way, though fertilizer rates may be purposely kept low as in the Northern part of Area 15. A small acreage of maize is being grown on such a part as a fodder crop for silage, and to gain experience in handling the crop for this use.

Arable Rotation Trial. This trial was started in 1956 on Area 14 and the rotation is:

Potatoes, Peas, Winter Wheat, Sugarbeet, Barley, Winter Barley.

Of the three fertilizer rates applied to each crop, two straddle the rate that might normally be recommended and often used in farm practice.

The fertilizer levels applied, in cwt/acre, are as follows:

AREA 14 (*see Map, page* **24**)

	Crop	Fertilizer	Low	Medium	High
A.	Winter Wheat	45 plus Aldrin	1½	3	4½
		S/A (in spring)	3 on half of each 'third'		
B.	Sugarbeet	49	4	7½	11
C.	Barley	42	2	3½	5
D.	Winter Barley	45	1	2	3
		S/A (in spring)	1	2	3
E.	Potatoes	41	6	12	18
F.	Peas	47	0	2	4

S/A = Sulphate of Ammonia.

Each break is approximately four acres, divided into 'thirds' for the three fertilizer levels. Since 1960 these have been randomized. With potatoes and sugarbeet these thirds are applied at right angles to the way they are applied on the other breaks, so that there are nine plots on each break, each harvested separately. After a number of years it might be possible from these results to conclude, for example, that the medium level was the most profitable in the case of sugarbeet but the high level was worth while in the case of potatoes. Such conclusions would apply to Levington soil climate and general growing aspects and they would vary with fluctuations in costs and prices.

Some indication of the residual values can also be gained by considering, for example, pea yields following potatoes. The high level of fertilizers on potatoes may leave sufficient plant foods in the soil so that only the low or medium level is necessary for the peas to follow.

Results from 6 Course Rotational Trial–Area 14

Over the four years of differential fertilizer applications for potatoes, sugarbeet, spring barley and oats (now replaced by winter barley) the medium level has on average been the most profitable. For peas the low level (1½ cwt of Fisons 37 in 1956, 1957 and 1958 and nil in 1960) has tended to be the most profitable. For winter wheat the lowest level of autumn dressing (in 1958 1½ cwt of Fisons 35 plus Aldrin and in 1960 1½ cwt of Fisons 45 plus Aldrin) together with the high level of top dressing was the most economic. For winter barley, first introduced into the trial in 1960 in place of oats, the highest level was the most economic but one year's result is not a reliable guide.

Levington Farms

It must be emphasized that these results refer to the particular conditions at this farm, and that with this type of trial four years' results are insufficient for conclusions to be drawn.

The percentage composition of the fertilizers mentioned is as follows:

	N	P_2O_5	K_2O
Fisons 45	6	15	15
Fisons 35	5	12½	12½
Fisons 37	0	16	16

Mixed Farming Rotation Trial. All breaks in this trial in Area 15 were established by 1959 under the following rotation:

Winter Wheat, Sugarbeet, Barley (undersown), 3 years Lucerne, Kale, Barley, Barley (undersown), 3 years Timothy/Meadow Fescue/clover ley.

As in the case of Arable Rotation Trial, three fertilizer levels are applied (cwt/acre) as follows:

AREA 15 (*see Map, page* **24**)

	Crop	Fertilizer	Low	Medium	High
A.	Sugarbeet	49	4	7½	11
B.	Winter Wheat	45 plus Aldrin	1	2	3
		S/A (in spring)	1½	3	4½
C.	Grass/clover ley – 3rd year	47	0	1½	3
		S/A	0	1½	3
D.	Grass/clover ley – 2nd year	47	0	1½	3
		S/A	0	1½	3
E.	Grass/clover ley – 1st year	S/A	0	1½	3
F.	Barley (undersown)	47	1	2½	4
		S/A	1	1	1
G.	Barley	42	2	3½	5
H.	Kale	41	4	8	12
		S/A	0	2	4
J.	Lucerne – 3rd year	47	2	4	6
K.	Lucerne – 2nd year	47	2	4	6
L.	Lucerne – 1st year	47	2	4	6
M.	Barley (undersown)	47	1	2½	4
		S/A	1	1	1

The percentage composition of the fertilizers used in these rotation trials is as follows:

	N	P_2O_5	K_2O
Fisons 41	10	10	18
Fisons 42	16	9	9
Fisons 45	6	15	15
Fisons 47	0	14	28
Fisons 49	14	6	20
Sulphate of ammonia	21	—	—

Each break is of approximately two and a half acres, again divided into randomized thirds for the three fertilizer levels. The fertilizer levels on the arable crops are applied at right angles to the way they are applied to the leys and lucerne. For the arable crops, there are nine plots, each harvested separately, so that the residual effect of the fertilizer levels applied to the leys can be measured. The ley and lucerne breaks are cut or grazed in their respective thirds.

As in the Arable Rotation Trial, information will be obtained on economic levels of fertilizer application. In addition, the nutritional contribution made by these leys to subsequent arable crops will be assessed.

The area to the north of this trial in Area 15 at present in winter wheat is subject to controlled fertilizer treatment as it is being held in reserve for long term and rotational experiments.

Livestock. Sheep and cattle are required for some experiments and for the large-scale trials mentioned above.

A small flock of Suffolk ewes is kept for early lambs and these are used for grazing on the large-scale farming trial and young female animals from the dairy herd at Red House Farm are also available. Additional store sheep are kept for the grazing of experimental plots.

Farmyard manure is required for some agricultural experiments and also for the Horticultural Unit. The manure from the dairy herd at Red House Farm is supplemented by dung from bullocks fed in yards at Walk Farm.

Crop Varieties. As the land resources on the farms at Levington are fully utilized examining the numerous aspects of nutrient responses and fertilizer formulations, it is not possible to consider the agronomic aspects of nutritional differences of crop varieties. For this reason well proven varieties suited to the soil and the climate are selected for experiments and trials, and these are:

Winter Wheat	Cappelle Desprez
Barley	Proctor
Potatoes	Majestic
Sugarbeet	Hilleshog 'E'
Kale	Marrowstem and Canson
Peas	Harrisons Glory

Proctor barley has been drilled this year in winter as well as spring, since Pioneer winter barley compared unfavourably in yield with Proctor in 1960. Professeur Marchal winter wheat, King Edward potatoes, Klein E and Triplex M sugarbeet are also included in this year's commercial cropping for comparative purposes.

Walk Farm is managed to provide facilities and the right soil conditions for fertilizer experiments and trials on arable crops, but apart from certain conditions thus imposed on fertilizer levels, the land is farmed with the usual cultivations, including crop spraying. Profit from crops under these conditions is difficult and is not a primary objective, but with the cost of experiments and the additional recording on the large-scale trial discounted, a profit can be achieved. The profit motive is an inherent part of the large-scale trials.

RED HOUSE FARM – 100 acres

The soil types on Red House Farm cover a wide range from light sand to heavy clay as a result of the topography. The farm is on the edge of the plateau between the Deben and Orwell estuaries and the main physical feature is a small valley leading down to the Orwell estuary. The result is that this farm is far less suitable on the whole for fertilizer experiments than Walk Farm. However, the dairy herd is used as required for special grazing experiments involving the animal and where the soil is relatively uniform, fertilizer experiments mainly on grassland, are carried out.

The Dairy Herd and Cropping. The Red Poll herd of up to fifty milking cows with selected female followers is managed on the principle of cheap milk production from good grass throughout a long grazing season and home-grown bulk food supplemented by concentrates in winter.

The Red Poll herd was founded in 1956 with 10 non-pedigree cows and 10 pedigree heifers. Further additions were made in 1957 and 1958, but since then home-bred heifers have been available for herd replacements. At first reliance was placed upon artificial insemination, but for inexplicable reasons the conception rate was dissappointingly low and a stock bull was purchased in 1958. There have been fewer breeding problems in recent years.

With up to forty cows in milk at any one time, the herd is run as a one-man unit. The herd average from the last completed lactations of the cows and heifers was approximately 750 gallons. The aim is to raise this herd average to 900 gallons.

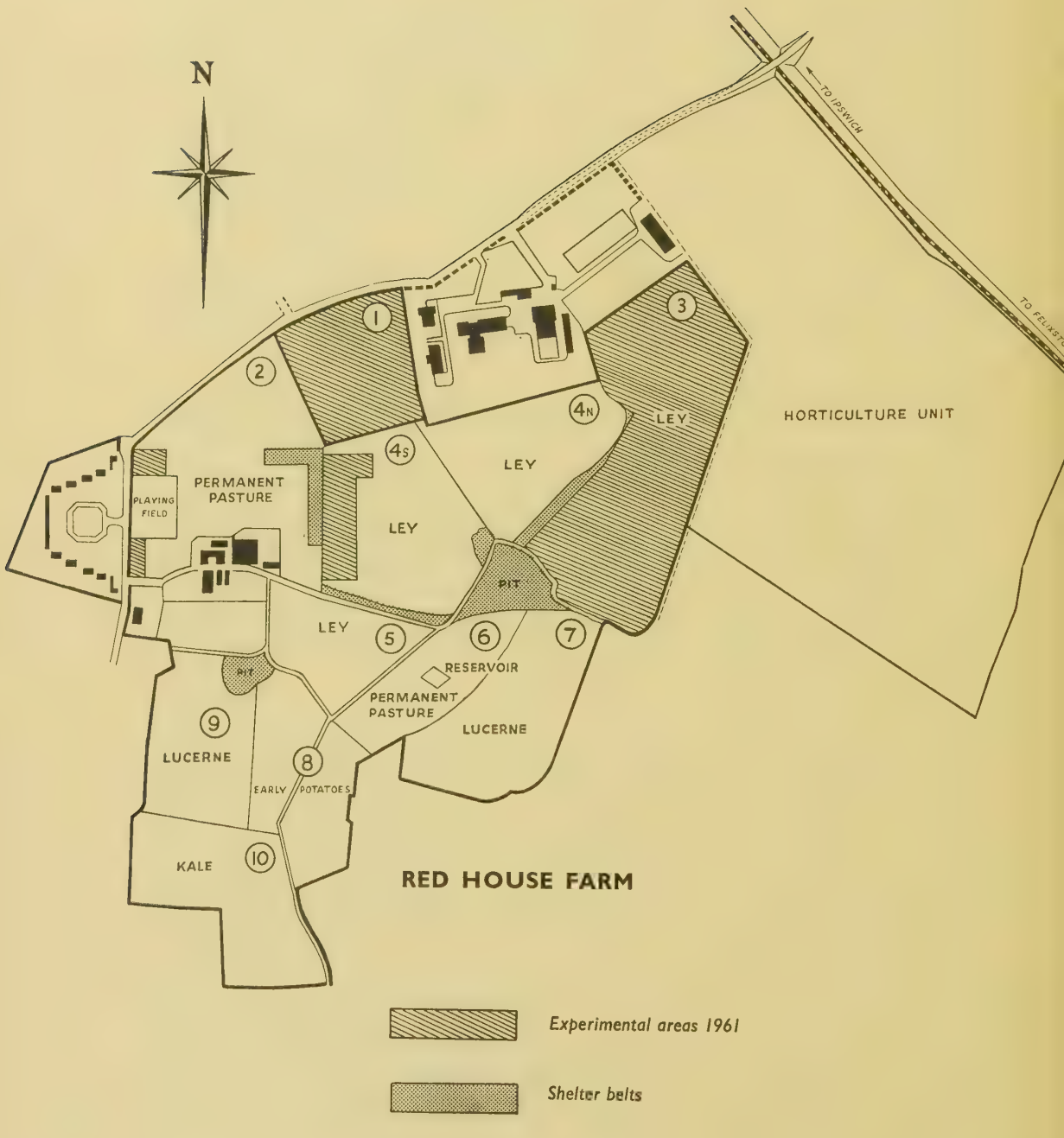
Accommodation is provided by a composite building including milking parlour and dairy, two covered yards with feeding passage, implement shed and dutch barn storage for hay and straw, all under one roof. In addition there is a range of loose boxes, calf pens, meal barn and open yard converted from existing old buildings.

An irrigation plant capable of watering all Red House Farm has been installed this year. Water is pumped from a borehole used by the Horticultural Section during the day and at night for the farm to a small storage reservoir in the clay, and thence pumped in daytime through sprinkler lines on the farm. The equipment is capable of applying 1 inch of water on 3 acres in $3\frac{1}{2}$ hours.

Such a system is an insurance against the ever present threat of seasonal droughts referred to earlier, will make greater intensification possible and lead to higher production as a reward for the financial outlay.

There are eleven fields on the farm. Two fields are in permanent grass (one is an accommodation field adjacent to the buildings and the other has changing soil strata and contours making for difficult drainage). Another field is devoted entirely to field experiments. Two more are in lucerne for without irrigation they were too sandy and dry to grow anything else; the remaining six fields are in a ley farming rotation. At first Cocksfoot/Clover leys predominated and based on yield data from experiments Timothy/Meadow Fescue/White Clover leys were tried. The productivity of both was severely restricted by prolonged droughts in late spring and summer. More recently short rotation ryegrass unaccompanied by clovers with the possibility of earlier growth has been much more promising.

It has been the experience that white clover in a mixed sward has been both difficult to establish and maintain on these light soils in a rainfall region inadequate for continuous production throughout the growing season. This experience is quite different from that gained on the farm of the Grassland Research Section in Devon where the soil and rainfall contrast sharply with the conditions at Levington. It is of sufficient importance to be included in that Section's research programme. A reappraisal of the place of clover in the irrigated grazing sward on this land awaits attention.


N
TO IPSWICH
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1
2
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LUCERNE
9
LUCERNE
8
EARLY POTATOES
KALE
10
RED HOUSE FARM
Experimental areas 1961
Shelter belts

Cropping and Fertilizers 1961

Field No.	History	Crop	Fertilizers Type	cwt/acre
1	Restricted fertilizer for five years	Grass and arable experiments	Experimental fertilizers	
2	Reseeded 1958 (part) 1960 (part)	Perennial ryegrass/ white clover for perm. pasture	48 S/A	3 3 × 3
3	Seeded after early potatoes 1959	H.1 Ryegrass ley	Experimental fertilizers	
4N	Undersown in barley 1958	Cocksfoot/clover ley	48 S/A	3 3 × 3
4S	Direct reseed 1960	S22 Ryegrass ley	48 S/A	3 3 × 4
5	Seeded after early potatoes 1960	H.1 Ryegrass ley	48 S/A	3 3 × 3
6	Drained; renovated 1957	Old pasture	48 S/A	3 3 × 3
7	Reseeded 1960	Lucerne	45 47	3 3
8	Kale 1960	Early potatoes	41 plus Aldrin	12
9	Reseeded 1959	Lucerne	47	2 × 3
10	Cocksfoot ley 1956–60	Kale	41	10

Note. The rate of sulphate of ammonia per acre used on any one field during the season depends upon the management requirements of the field, and the extent to which reliance is placed upon the presence of clover, its contribution and the frequency of irrigation. It may be more or less than planned.

The percentage composition of the fertilizers used in 1961 on the farm is as follows:

	N	P_2O_5	K_2O
Fisons 41 plus Aldrin	10	10	18
Fisons 45	6	15	15
Fisons 47	0	14	28
Fisons 48	0	20	20
S/A	21	—	—

S/A = Sulphate of Ammonia.

Levington Farms

Manurial Reference Trial – Field 1. This is intended to illustrate visually the effects on crop growth resulting from the presence and absence of the three major nutrients and farmyard manure on soils typical of the locality. The trial consists of thirty-five plots with the following treatments:

Nil, NP, NK, PK, NPK, NPK + FYM, FYM.

These are at rates of application regarded as best suited to the normal requirements of the crops.

The crops, specially chosen for greatest visual response, are in the following rotation:

Potatoes, Sugarbeet, Barley, Red Clover, Kale.

Hypomagnesaemia Investigation – Field 3. The factors affecting hypomagnesaemia in cattle and sheep are recognized as being complex but they can be associated with the magnesium available to the animal in its feed. Supplementary feeding of magnesium compounds is commonly employed as a preventive but the investigation on this ley examines the possibility of increasing the animals' intake of magnesium by the application of magnesium compounds to increase the magnesium content of the grass. The treatments are assessed by their effect on the magnesium content of the cows' blood serum over the spring grazing season and this on Red House Farm can be at a critically low level and can be associated with hypomagnesaemia symptoms.

A relatively high incidence of hypomagnesaemia has occurred on this farm since 1957 so that its fields are very suitable for such an investigation. The uptake of magnesium by herbage species in relation to nitrogen, phosphate and potash nutrition has been studied since 1956 and in 1959 dairy cows were introduced into a grazing experiment. This will continue for a number of years on Field 3 and supplementary experiments on this subject using barren ewes began this year on Field 4.S. Herbage from this area has been supplied to other research stations for extended animal studies. The work is more fully reported in the Agronomic Experiments section on page 56.

Horticultural Unit

The Horticultural Unit consists of sixty acres planted with a range of crops to provide facilities for investigations on fertilizers, herbicides, insecticides and fungicides. Twenty-eight acres are planted with apples and pears, an area of twenty acres is available for vegetable crops, half an acre of glass is devoted to tomatoes, cucumbers and carnations, five acres of fine turf cover investigations on lawns and two acres are planted with a complete range of plants grown in gardens. All crops are grown to the highest standards. The results obtained from research projects are, therefore, of direct interest to all commercial growers within the industry and to amateurs. The 'Wright Rain' system of irrigation, with water from a deep well, is designed to cover the complete Unit. Irrigation is used where necessary as a normal cultural operation, but irrigation equipment will also be used for experimental purposes.

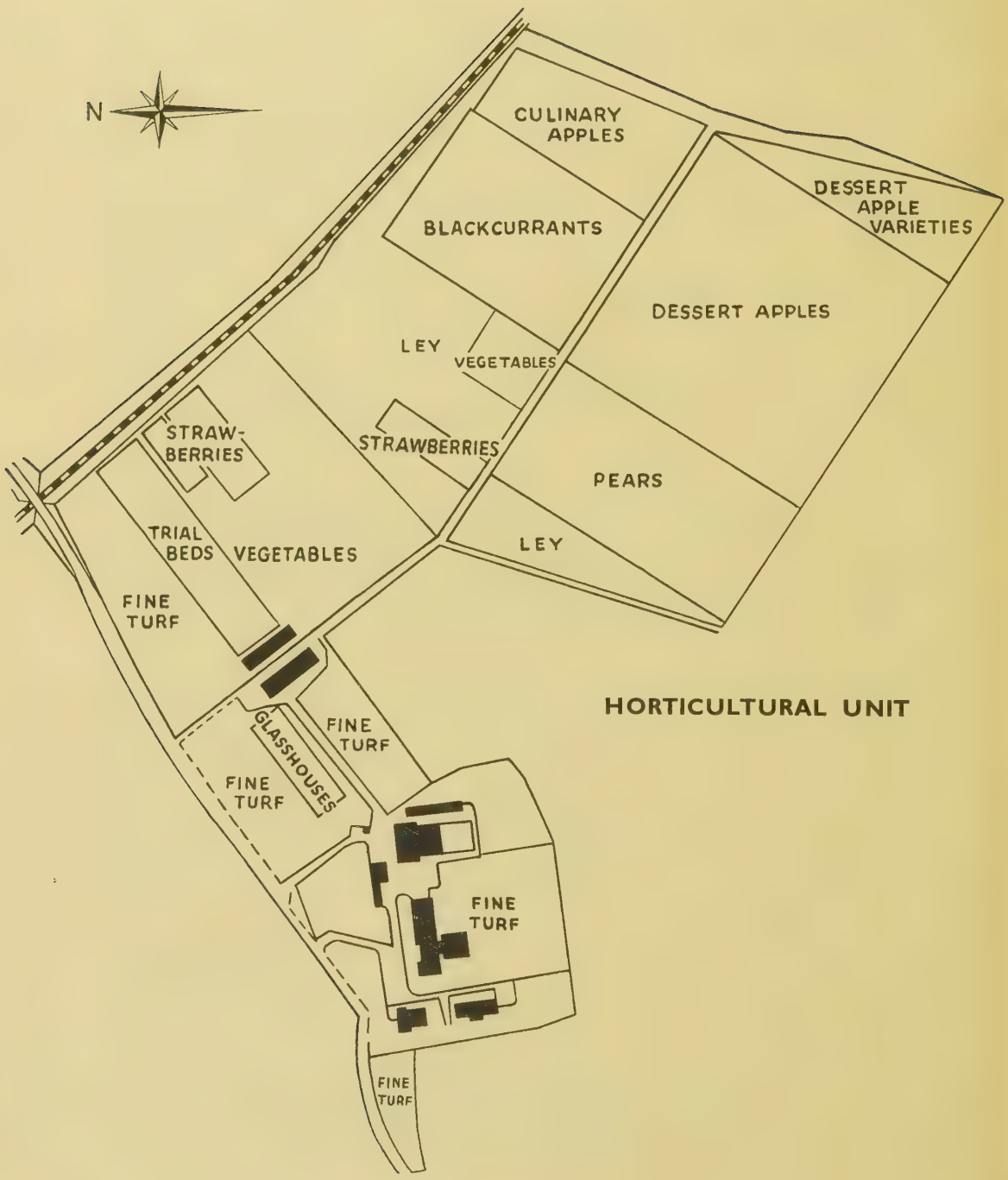
Fruit

The fruit areas on the Horticultural Unit were cropped with farm crops prior to 1955 when present development was started. The soil is mostly fine, sandy loam overlying coarse loamy sand, although near the south-eastern corner of the apple orchards there is an area of heavier soil. Initially sub-soiling was carried out to break up a plough pan. Planting of top fruit and blackcurrants took place in November 1955.

Apples and Pears. Fifteen acres of dessert apples planted twenty feet square consist of three main varieties – Cox's Orange Pippin, Worcester Pearmain, and Tydemans Late Orange. The first two of these were chosen as they are the most widely planted commercial varieties, whilst the third is a newer but increasingly important type. The three varieties give adequate pollination and a succession of maturity, spreading the picking season and allowing a large proportion of the crop to be stored if necessary. A small collection of other varieties is also grown for observational experiments. The rootstock MXVI was used throughout after consultation with other research organizations.

An area of five acres of culinary apples was also planted in 1955. The main variety is Bramley, with pollinators of Grenadier and Edward VII. These varieties are common commercially and give a succession of picking. The rootstock used here is MII, and the planting distance twenty-four feet square.

The pear plantation covers eight acres, and the varieties used are Conference, Bristol Cross and Williams Bon Chretien. All are worked on Quince A stock, but the last two varieties are double worked to avoid incompatibilities between rootstock and scion. Planting distance is twenty feet square.



HORTICULTURAL UNIT

Maiden trees were planted throughout and all the top fruit has been pruned to a delayed open centre form. Growth of the culinary apples and pears was rather less vigorous than desirable in the first two years after planting, but has improved considerably. Dessert apples have grown vigorously and in the winter of 1958–9 pruning was deliberately light to encourage fruiting and consequently in 1959–60 considerable thinning of growths had to be undertaken. The first light crop of top fruit was taken in 1959. Hitherto all the orchard has been clean cultivated, but the dessert apples were grassed down in 1960, using a Rhys William orchard seed mixture and a very satisfactory sward has developed.

Since the soil is light and prone to drought, good establishment of the trees was essential before experimental differentials were applied. In view of this, uniform fertilizer and cultural treatment have been given to the major portion of the orchards and the trees heavily mulched with straw to conserve moisture in the soil. This reserve area will be used for experiments in the future.

As establishment was likely to be difficult, two small experiments were laid down on dessert apples and pears to study establishment methods. Whilst demonstrations of nutrient deficiencies were laid down on all three crops.

Blackcurrants. Three varieties were planted in 1955. They were selected to give a succession of fruiting, and are all widely grown types. Mendip Cross ripens first and is followed by Wellington XXX and Westwick Choice. The 'hedge' system of planting was adopted with bushes spaced four feet six inches apart in rows nine feet apart. Bushes are mulched with straw except where experimental needs demand otherwise. After planting, bushes were cut to within an inch of the ground, and this severe cutting back was repeated twelve months later. This treatment delayed cropping so that the first crop was not taken until 1958, but it resulted in very good growth of bushes. The first crop amounted to thirteen and a half tons, the second to nine tons and the third to sixteen tons from five acres.

Practically the whole of the blackcurrant area is laid down to experiments, covering nutritional factors and weed control. The nitrogen, phosphate and potash requirements are under investigation. Both nitrogen and potash have increased yields, but there has been no response to phosphate. Different organic and inorganic sources of nitrogen gave similar responses. Straw mulching improved growth and yields considerably in the early stages, but in 1959 the presence of straw mulch resulted in lower yields due to increased frost damage. Simazine proved an effective weed killer amongst blackcurrants. The possibility of a long-term build up of weed killer in the soil, and its effect on growth and cropping, are still under investigation.

Strawberries. An acre of Royal Sovereign strawberries was planted in the spring of 1956. A pre-planting dressing of 30 tons per acre of farmyard manure was ploughed

in, and plants were de-blossomed in the summer of 1956. Experiments on the nitrogen, phosphate and potash requirements and nitrogen sources were laid down, but no differential responses were recorded. After three crops the area was ploughed up in 1959.

A further acre of the same variety was planted in autumn 1956 and devoted to similar experiments. Again the plants were de-blossomed in the maiden year, and three crops have so far been taken from this area.

Non-nutritional experiments on strawberries have centred around the chemical control of runner development. On the variety Royal Sovereign a single application of 0·1 per cent maleic hydrazide effectively controlled runner formation without impairing vigour or reducing yield in 1958. Since then investigations have been extended and now cover six widely grown commercial varieties, namely Royal Sovereign, Huxley Giant, Cambridge Favourite, Cambridge Vigour, Talisman and Red Gauntlet. With all varieties at 0·1 per cent there has been no reduction in yield or vigour of the plant, but the degree of runner inhibition has shown variability from variety to variety, some being more responsive than others. Results have also been variable from one year to the next within a variety; it is possible that climatic variations have influenced this effect. Investigations into these problems are continuing.

Vegetables and Outdoor Flowers

Approximately twenty acres of land is available for vegetable research. Nutritional experiments on vegetables and flowers present a particular problem, since after the application of different fertilizer treatments for a short-term vegetable or flower crop considerable residual nutrient differentials may remain. The land needs to be brought to a uniform nutritional level before further experiments can be laid down. This is done by putting the land down to ley for several years; the grass is cut and removed for fodder.

Since 1956 various subjects have been investigated in relation to vegetable and flower crops. Nutritional experiments on lettuce, carrots, cabbage and broccoli have been concerned with comparisons of nitrogen sources. Particular attention has been paid to ureaformaldehydes which so far have shown no great advantages over other sources. Aldrin incorporated in fertilizer gave a very satisfactory control of cabbage root fly, but experiments on carrot fly control were inconclusive due to low pest infestation.

Maleic hydrazide applied to the foliage of red beet and lettuce in an effort to inhibit bolting did not prevent the formation of the inflorescence, although elongation was prevented.

A special formulation of maleic hydrazide has also been found to control the growth of various hedges, especially privet. It will successfully retard the growth of privet

Two acres of garden plants are available for testing fertilizers and spray chemicals.

Carnation blooms in nutrition experiments are scored and graded for quality.

Fertilizer responses in fine turf are assessed by weighing three one-foot wide cuts from each plot.

Girth measurements of young fruit trees are made annually.

for up to about three months from the time of application, thus very considerably reducing the need to cut the hedge. Investigations on other hedge species are progressing.

Gibberellic acid was used on a wide range of flowers and vegetables and many previously reported effects have been confirmed. On the whole, little or no benefit was gained from its use, as there were usually undesirable side effects.

The systemic insecticide, Rogor, was investigated on flower and vegetable crops (and also on fruit). Besides giving good control of pests, Rogor was safe for use with edible crops provided there is a seven-day interval between treatment and harvest.

Trial Beds

A wide range of outdoor plants, commonly found in amateur gardens, is supplied by a unit set up in the winter of 1958–9 and is used for general testing of products after detailed tests on a few species specially selected and grown for the purpose.

This area, two acres in extent, was ploughed out cocksfoot ley and was divided into four equal-sized strips, separated by wide paths. In these strips will be found most plants grown in the average garden, as well as many that deserve greater popularity. The area has some two hundred and fifty different shrubs, one hundred and sixty different herbaceous plants, a sixty-five variety rose collection and very large annual flower, dahlia and chrysanthemum collections. All the common vegetables and herbs and many popular fruit varieties are grown. This unit has been widely used for insecticide and herbicide investigations in 1960.

Glasshouse Crops

The glasshouse unit, covering half an acre, was erected in winter 1955–6. There are nine commercial glasshouses connected on their northern end by a glasshouse corridor. Four of the houses are joined in blocks; others are built separately for crop isolation. Between these latter houses are cold and heated frames used for plant raising.

The six vinery-type houses, one propagating house, and two cucumber houses are built in traditional style but incorporate several modern features. The light, already of high intensity in this area, is further improved in the houses by using glass twenty-four inches wide – thus reducing the number of roof bars.

The heating system is high-speed hot water through one and a quarter inch pipes designed to give the even heat essential for experimental purposes. House temperatures are thermostatically controlled through a system of motorized valves. The heating pipes are detachable for easy removal during winter routine operations.

A direct steam line laid to each house for soil sterilization was used during the winter 1959–60 when the soil in all five tomato houses, the carnation house and both cucumber houses was steam sterilized for the first time. In view of root knot eelworm incidence, soil sterilization was again undertaken in the winter 1960–61. To avoid soil

transference from one experimental plot to another, single pipes fitted with spikes are used after the soil has first been dug.

Tomatoes. This is the largest glasshouse crop and occupies five glasshouses. The first experiments were started in the heated houses in 1957 after a cold crop had been taken in 1956.

Nutrient experimental work with tomatoes at Levington, as with most other crops, is carried out on a crop grown to the highest standards. To this end cultural techniques are adopted giving the plants in the early stages higher temperatures and humidity than are sometimes given in the industry. Careful training of the plants after they have reached the top of the wire is necessary to ensure that the fruit is picked within the correct plot. The method used is to train the unstopped plants over the double planted row and down the opposite plant.

The varieties Potentate and Ware Cross are used for all experimental work in the glasshouses. They are widely grown in the industry as they are capable of producing heavy weight, though often poor quality – which is likely to be accentuated with adverse fertilizer treatment. As they are small-rooted varieties they respond quickly to fertilizers. It has been found necessary to apply large amounts of water due partly to the extremely open nature of the soil. A rate of thirty-five thousand gallons per acre per week was applied during part of the hot summer of 1959.

An annual dressing of farmyard manure has been applied, mainly with the object of increasing the water-holding capacity of the soil, and some improvement in the soil condition since 1956 is apparent.

Experimentation on tomatoes is with a standard size plot of twenty-four plants grown in a double row with the end plants treated as guard plants, yields of which are not included in experimental results. To avoid the risk of solid top dressing fertilizer being spread from one plot to another during watering, asbestos edging is erected. This edging is taken up at the end of each crop, sterilized, and replaced before planting.

In an experiment comparing varying rates and dilutions of liquid fertilizer with solid feeding no differences in total yield appeared in 1957, 1958 or 1959. Differential effects on quality have been observed. This experiment is continuing.

A long-term experiment on tomatoes is being carried out to examine various rates and combinations of phosphate base dressing and nitrogen, phosphate and potash top dressings. In 1959 as in 1958 and 1957, no improvements in yield or quality were obtained above the minimum nutrient rate applied. Few clear cut differences were expected on new glasshouse soils and the experiment will continue to examine long-term nutrient build-up.

An experiment compared a number of organic and inorganic sources of nitrogen applied as top dressings at equivalent nitrogen rates. In this short-term investigation on a new tomato soil, no substantial differences were observed. The experiment has been concluded after three years and the two houses which it occupied are now being used for an extension of the liquid feeding programme.

Throughout the four years of heated cropping from all experimental treatments, yields have averaged from 80 to 56 tons per acre.

Other experiments on tomatoes have been carried out on pot grown plants and have included an examination of plants grown by the ring culture system, gibberellic acid and its effect on fruiting and the effect on plants of gypsum induced low pC readings.

Carnations. The first carnation crop at Levington was planted in late February, 1957; cutting started in July, 1957, and the crop was removed at the end of 1959. The plants cropped at an average of forty-two blooms per plant during this period. Several different varieties were grown. Different coloured varieties were planted as guard rows to separate the plots, and this assisted speedy and accurate cutting and recording.

In an experiment to examine the effect of various nitrogen and potash rates and nitrogen sources, no significant results were obtained.

Fisons L.5 was found to be as efficient as Fisons G.H.5 as a top dressing in a comparison between liquid and solid feeding of carnations. It appeared, for the first eighteen months of cutting, that a liquid feed of medium concentration fed frequently gave slightly more blooms than any other treatment.

Both experiments are being repeated in a modified form on the new crop of carnations planted in February, 1960. To prevent root growth from one plot to another, which may have been influencing previous experimental results, permanent asbestos sheets have been placed between the plots to a depth of eighteen inches.

Cucumbers. This crop has been outstanding for the three years 1957, 1958 and 1959. In 1958 a total crop yield of ten tons one hundredweight was obtained from four hundred feet of bed, or two and three-quarter flats per foot. This result was obtained from an end of February planting and the plants continued fruiting until the end of September. In 1960 a severe attack of root knot eelworm affected yields and experimental results.

The only experiment carried out on this crop was to study the effect of substituting inorganic for organic nitrogen in the base and top dressings. Results so far have shown the one to be as effective as the other but it should be noted that for the first three years new beds have been used for experimentation. In future, the old bed will be retained for use after steaming and this change in technique, common in commercial

practice, may shed light on the relative values of organic and inorganic fertilizers. As with the carnations, divisions have been erected to limit the spread of roots in the bed and base soil.

All tomatoes, carnations and cucumbers are graded for size and quality before being recorded and marketed. Experimental results are based on these factors as well as weight.

Decorative Plants. In the corridor connecting the glasshouses, as well as in the propagating house for a large part of the year, decorative plants provide a wide range of material on which products are tested.

Experimental Turf

In 1956 an area of one and a half acres to the north of the glasshouses was established for fine turf experiments. Initially half of this area was sown with a seed mixture consisting of fescue and browntop and half with a mixture of S.23 perennial ryegrass and H.1 short rotation ryegrass. The ryegrass section was replaced by a fescue-browntop sward in 1957.

Since 1956 the area devoted to turf experiments has been gradually increased. In 1957 two and a half acres were added. Approximately three-quarters of an acre of this was sown with a seed mixture containing wild white clover so that weed control experiments could be conducted on a sward which contained a uniform infestation of at least one common turf weed. Clover was chosen as being a relatively resistant turf weed and as such, one which is useful as an indicator plant when the potentialities of different herbicides are being considered. An area has been sown with a seed mixture containing other common turf weeds so that a sward with a uniform infestation of these will be available at Levington for future weed control experiments. The remainder of the experimental turf which was established in 1957 was sown with seed mixtures containing fescue and browntop and in addition some crested dog's tail was included on one area.

A further acre of turf for experimental purposes was sown in the spring of 1959. This area which was sown with a seed mixture containing fescue, browntop, crested dog's tail and rough-stalked meadow grass completes the five acres at present devoted to turf experiments.

Turf experiments consist of both short-term investigations and long-term projects which are designed to improve existing turf fertilizers and weed killers and to formulate new materials for the treatment of all types of turf, including sports grounds and ornamental lawns, which will be more efficient and less costly than existing treatments.

The turf experimental programme covers three main subjects, namely, nutrition, weed control and moss control. In addition, experiments have also been conducted on the growth inhibition of turf grasses with maleic hydrazide.

Nutrition. The main aspects of turf nutrition under investigation are the effects of sources and rates of nitrogen, phosphate and potash on sward growth and composition. A long-term investigation to study changes in botanical composition over a period of several years is in progress, from which information will be obtained on the most suitable materials to encourage the fine leaved, desirable turf grasses whilst discouraging weed growth. The comparison of spring and autumn applications of phosphate and potash is also being made.

The value of organic nitrogen sources in turf fertilizers is being investigated. The nitrogen in these sources is more slowly available and it is possible that with the right materials the response to a nitrogen turf fertilizer can be extended.

The conditions under which scorch is most likely to occur with liquid fertilizers have been defined and different nutrients are being examined at various rates under these conditions to obtain information on the concentrations that do not cause scorch.

Weed Control. As mentioned above, an area was sown in 1957 with a grass seed mixture containing a small percentage of wild white clover which is a very common turf weed and considered to be a useful indicator plant with which to examine the potentialities of different herbicides. Since 1957, experiments have been conducted on this sward. Various herbicides in aqueous solution and in combination with powdered and liquid fertilizers have been examined and some treatments have given a very good and prolonged clover control.

In addition to the weed control work at Levington, many of the experiments which were initially put down at Levington have been repeated elsewhere on swards containing weeds other than clover to examine the effect of the herbicides on as many different weeds as possible.

In these weed-control investigations, the use of a logarithmic sprayer has enabled very many concentrations, rates of application and combinations of herbicides to be examined.

Moss Control. Mosses can be classified into two groups, Pleurocarpous and Acrocarpous. Pleurocarpous forms occur most frequently in turf, but Acrocarpous forms are also common, especially on intensively managed swards which are mown very keenly, such as bowling and golf greens. Since 1957, experiments have been conducted with various chemicals on swards containing both types of moss although, due primarily to its availability, the emphasis has been on Pleurocarpous forms.

The results of the moss control experiments have indicated that Lawn Sand containing sulphate of ammonia, sulphate of iron and a small percentage of calomel gives the most rapid and prolonged moss control, but that Lawn Sand without calomel will give a good initial control which could be sustained with correct management. It is questionable whether the extra expense involved with the use of calomel is justifiable.

Horticultural Unit

Growth Inhibition. Since 1956, several experiments have been conducted with maleic hydrazide to examine its value in the inhibition of turf grasses. This work was carried out on ryegrass swards consisting of S.23 perennial ryegrass and H.1 short-rotation ryegrass, and on fine turf containing fescue, browntop, rough-stalked meadow grass and crested dog's tail. In both cases a good growth inhibition was obtained but the grass was discoloured. The discoloration was persistent and unacceptable. For this reason maleic hydrazide is considered unsuitable for the inhibition of turf grasses, at this stage of development.

Turf Grasses. During 1958 and 1959 a turf nursery was established to provide turf for demonstration purposes. This contains a section of sea marsh turf and an area which was sown with a seed mixture containing fescue, browntop, rough-stalked meadow grass and crested dog's tail.

In addition small plots of individual species have been established, using twenty different grasses which are commonly found in turf.

Ornamental Lawns

In addition to the turf for experimental purposes approximately three acres of ornamental lawns have been established at the Research Station since 1956. The two main front lawns were sown using a seed mixture containing fescue and browntop, and other lawns have since been sown using the same seed mixture. All the lawns were sown after extensive blade grading and cultivation of the top soil. In spite of the very light soil and the low rainfall which is a feature of this part of the country, the lawns developed satisfactorily under normal management. This consists of regular mowing – twice weekly when growth is vigorous – regular annual fertilizer treatments, occasional wire raking and spiking and weed control as necessary.

North Wyke Experimental Station

North Wyke Experimental Station supplies facilities for the Grassland Research Section of the Levington Soil Science Department.

The estate was purchased in the autumn of 1955 to provide facilities for grassland research in a typical grassland area. It is situated about three miles from North Tawton and seven from Okehampton, and is between 400 and 600 feet above sea level. The soil is predominantly culm measure clay and, with an annual rainfall of approximately 40 inches, is in complete contrast to the light soil and low rainfall conditions at Levington.

The Manor House dates from the fourteenth century and has been much altered and restored through the ages, notably in Tudor and Stuart times. It was owned by the Wykes or Weekes family for centuries and the Royal Arms of the early Tudor period, carved in stone, are inset above the Gate House to commemorate visits by the Royal Princes Arthur and Henry, sons of Henry VII. Extensive restorations to the house were carried out in 1895. It is included in the list of Buildings of Special Architectural and Historical Interest and is noted for its beautiful ashlar work.

The Manor House has been modified internally to provide residences for the officer-in-charge and the farm manager, a conference room, library, offices, laboratories and a canteen. Some of the existing farm buildings have been converted to provide an oven room and a cold store and also housing for experimental animals, and facilities for the latter are to be extended. Four new cottages have also been built.

Grassland Research Programme

The Section is investigating the production and utilization of herbage from grazed swards as it is affected by nitrogen, phosphate and potash applications. Both yield and quality of herbage are considered with particular emphasis on the contribution from clover.

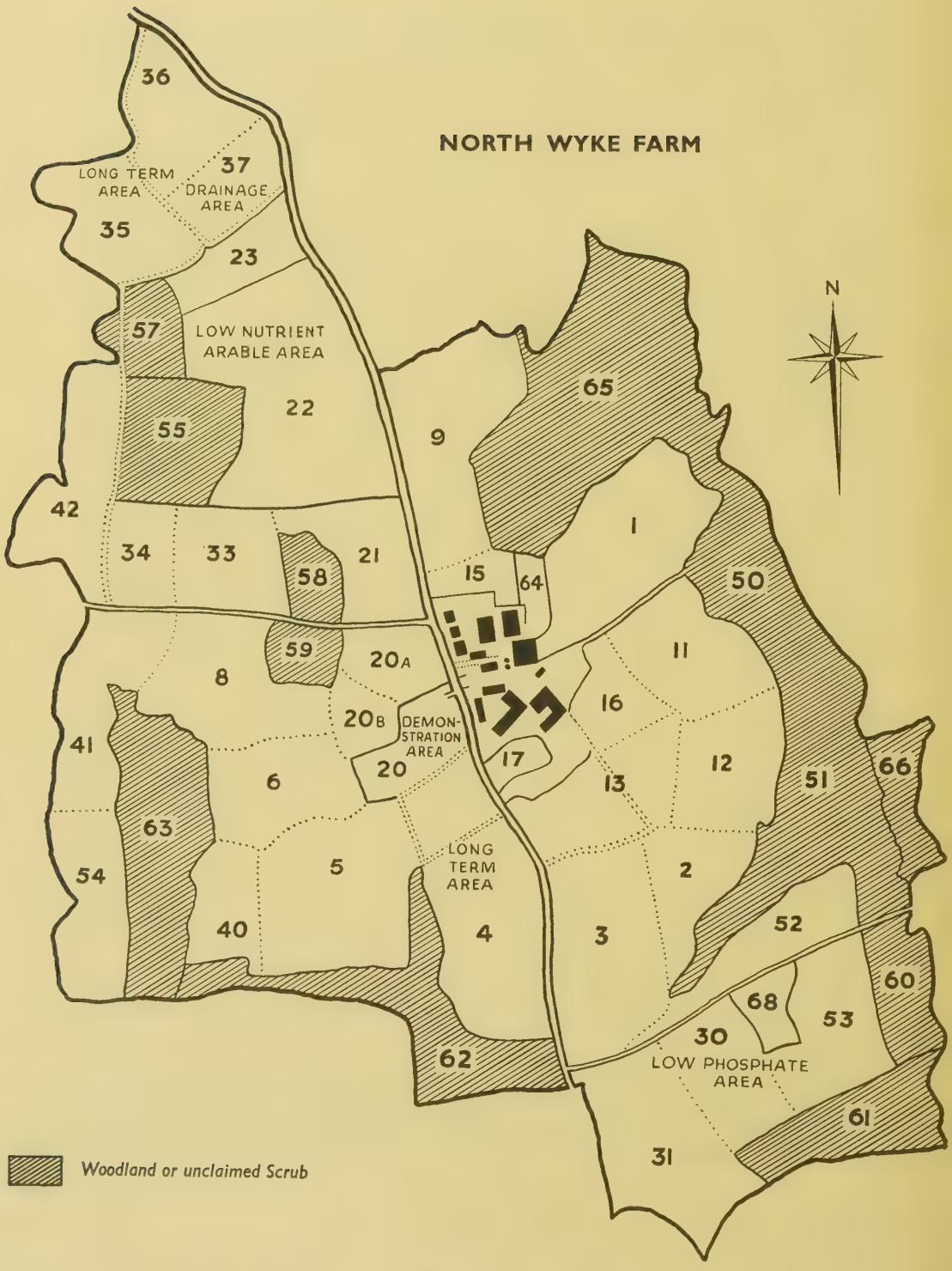
The research programme can be considered in three aspects:

(a) Experimental Technique, which is particularly complicated in experiments where the animal is employed.

(b) Herbage Production, in which results are expressed as herbage yields.

(c) Herbage Quality, where the results are measured by digestibility assessments or in terms of animal product.

Experimental Technique. As a first step, a series of experiments has been initiated to clarify the experimental techniques that will be used in grassland experimentation at North Wyke. In such a complex subject, the use of the correct techniques is essential if comparable and valid methods of assessment are to be used for investiga-


NORTH WYKE FARM
N
36
37
LONG TERM AREA
DRAINAGE AREA
35
23
57
LOW NUTRIENT ARABLE AREA
22
55
65
9
1
42
34
33
58
21
15
64
50
59
20A
8
11
20B
DEMON-STRATION AREA
16
41
20
17
12
51
66
6
13
63
LONG TERM AREA
54
5
2
40
4
3
52
60
68
53
30
LOW PHOSPHATE AREA
62
61
31
Woodland or unclaimed Scrub

tions into different aspects of the main problems. These techniques may have to be modified as more information on them is obtained.

The technique studies at present being undertaken include investigations on:

(a) methods of maintaining pure stands of grass and clover,
(b) the effects of 2,4,5,-T when used as an eradicant for clover from a grass sward,
(c) the suitability of a range of sampling implements under a variety of conditions,
(d) the errors associated with short-period grazing and feeding experiments,
(e) the use of artificial grazing methods and the management of grassland in provincial experiments,
(f) the use of lactating goats as substitutes for cows.

The last of these investigations is of particular interest, in that it offers economy of plot size and feeding stuffs combined with experimental flexibility, but as yet little is known of the relative performance of goats and cows on different foods, and more investigation is required before the goat can be accepted as a valid standard of measurement even for special purposes. Milking goats and dairy cows are being used to investigate short-period changeover techniques under grazing and indoor feeding conditions, and data are being collected to compare the performance of goats and cows.

The use of artificial grazing techniques may help to overcome the difficulties involved in employing the animal in field experiments and the Section is developing ideas published by other workers, as this type of technique may be increasingly used in the future.

Herbage Production. The second aspect of the programme consists of experiments in which the herbage is cut and no attempt is made to measure animal production. Such experiments are conveniently and advantageously conducted at sites on farms throughout Great Britain where sources of nitrogen, phosphate and potash, as well as times and rates of application, are investigated. The interpretation of results from experiments carried out in this way is limited by the particular conditions of harvesting with a cutting machine.

At North Wyke, this method is being used to study the differential response to fertilizers of grass species and for fundamental studies on the contribution of nitrogen from clover in a mixed sward.

Investigations into the response of pasture to fertilizer application are conducted by estimating herbage yields from grazed swards by means of sample cuts. In this way full account is taken of the return of nitrogen, phosphate and potash by the grazing animal.

Herbage Quality. The third aspect of the programme concerns experiments involving the estimation of animal production from grassland.

Herbage quality, as affected by fertilizer treatment is receiving attention and herbage

digestibility is measured by wether sheep in indoor trials. As suitable techniques are developed it is intended to estimate grass quality by the use of lactating goats or cows in grazing trials.

This third aspect of the grassland research programme will receive increasing attention as the work develops.

Animal health investigation will not normally form part of the research programme. An exception is the study of the relationship between fertilizer practice (for example, rates of nitrogen and potash application), sward composition and hypomagnesaemia. At Levington, in the last few years, the effect of adding magnesia to the soil has been studied both in herbage mineral content and in the blood serum levels of dairy cows grazing on treated herbage.

It is anticipated that the Grassland Research Section will be able to examine the conclusions derived from their grassland projects, on farms other than North Wyke and Levington. A wide range of grassland soil types and climatic conditions will be covered so that the research results will be evaluated under general rather than particular conditions.

Information on commercially grazed swards is being obtained from a Grassland Recording Scheme (see pp. 16–17).

North Wyke Farm

The prime requirement of the farm is to provide facilities for grassland research.

During the period 1955–60 the cropping has been designed to clean the land and improve or reseed all the older grass fields. A considerable amount of reclamation of rough grazing and scrubland was undertaken and hedges and ditches were removed and replaced with post and wire fencing where necessary. Much of the woodland collects the drainage from the surrounding agricultural land, but those areas which can be drained and reclaimed will be brought into the farmed area when possible.

A new shippon was built, and the cowshed that existed converted to calf houses and loose boxes. Additional accommodation for implements and better facilities for ensiling, storing dung and assembling animals have been provided. Mains water supply has been connected and all fields are watered from this source. The acreage changes which have occurred since the farm was purchased are summarized as follows:

	1955	1957	1959	1961
Agricultural land	193	231	257	265
Rough grazings	55	26	—	—
Scrub and woodland	130	121	121	113
Roads and buildings	8	8	8	8
	386	386	386	386

North Wyke Experimental Station

Livestock. A pedigree herd of attested Ayrshires was taken over with the farm in 1955. It is maintained to provide cattle for experimental use and to produce milk commercially, with 50 cows in milk all the year round.

All first-calf heifers and some of the dairy herd are served with a beef bull and their calves are sold at a few weeks old and the remainder of the dairy herd is mated with an Ayrshire bull to provide herd replacements.

The present herd consists of:

Cows	60
Down calving heifers	20
Yearling heifers	20
Heifer calves	10–15
Bull	1

A flock of Scotch half-bred ewes was purchased in 1957 and this has now been raised to 100 ewes which are mated with a Suffolk ram to lamb in March and April.

Grazing Management. The heavy clay soil restricts the grazing season to between April and October. All cattle are housed during the winter.

Dairy cows. The fullest use is made of electric fencing in strip grazing the dairy herd and back fences are used whenever necessary.

Dry stock. Dry cows and young cattle are kept on the outlying fields which they graze in rotation. Occasionally a bunch may be brought in to clear up behind the dairy herd.

Sheep flock. Shortly after lambing, ewes and lambs are confined to a suitable acreage of young grass managed on the forward creep grazing system. At the end of June the lambs are weaned and the ewes released for scavenging. The lambs are finished on new seeds or rape.

Cropping. That part of the farm which is not immediately required for experimental use is cropped on commercial lines. Future experimental requirements are, however, taken into consideration. Basically, the rotation is a system of long leys which are ploughed when necessary and put through a rotation of either rape and ryegrass or kale followed by S.22 ryegrass, before being sown out to a long ley again. It is intended that there will be at least 10 acres of kale and 10 acres of newly sown ryegrass every year in addition to an undefined acreage of rape and ryegrass.

The long-ley seeds mixtures that are in use are:

4 lb. Timothy S.48	6 lb. Timothy S.48
4 lb. Timothy S.51	5 lb. Meadow Fescue S.53
10 lb. Perennial ryegrass S.24	5 lb. Meadow Fescue S.215
1 lb. Montgomery LF Red Clover	2 lb. White Clover N.Z. Cert
1 lb. White clover N.Z. Cert	—— Mother
—— Mother	18 lb.
20 lb.	

In addition Cocksfoot/White Clover, Ryegrass/White Clover and Timothy/White Clover mixtures have been used.

Compound fertilizer use on these leys is in accordance with normal recommended levels and the quantity of nitrogen used varies with season and sward. The following rates of application are normally made:

Crop	Fertilizer	cwt/acre	Top dressing	cwt/acre
Grass: grazed	42	4	Sulphate of ammonia	2–4
hay or silage	41	4	Sulphate of ammonia	2–4
reseeding	45	4	Slag applied in seedbed	5
Kale	42	4	Sulphate of ammonia	2

Experimental Areas

Experiments may be sited on any suitable field on the farm but there are certain fields specifically reserved for certain types of experiment as indicated below.

Long-Term – Fields 4, 35, 36. On these fields long-term experiments will be down for an indefinite period.

Low-Phosphate Status Area – Fields 30, 31, 52, 53. A low-phosphate status is produced in these fields for certain types of experiment, particularly where the value of different sources of phosphate is being assessed.

Low-nutrient Arable Area – Field 22. Twenty acres are farmed in a rotation with controlled fertilizer usage to provide three acres per annum for critical comparison of different fertilizer sources, using arable crops as indicators.

Drainage – Field 37. Initially, six acres of land have been set aside for drainage experiments. Drainage of culm measure clay is of considerable interest and the first experiment considers top soil permeability. For this purpose the field has been thoroughly drained by a uniform system of tile drains and from 1961 the land will be used to study the effect of various treatments on the time and rate of drainage-water flow.

Demonstration Area – Field 20. Although the farm is used for research and experimentation, a small area of land has been reserved for a manurial reference trial and for grass species identification plots. The manurial reference trial demonstrates crop growth differences in the presence and absence of the major plant nutrients. A rotation adapted to local needs is employed and the effects are demonstrated on potatoes, cereals and grass.

Grassland research is centred on North Wyke Experimental Station. The Manor House has been converted internally for laboratories, offices and staff accommodation.

Techniques to measure grass in terms of animal production are being developed.

Botanical analyses are made of herbage samples.

Plant nutrition studies are carried out in the Pot Trial Unit glasshouses.

Agronomic Experiments

Field and pot techniques, based on established statistical concepts, are used. The results of these experiments ensure the satisfactory field performance of fertilizer materials derived from new raw materials and manufacturing processes and that sound, economic recommendations for fertilizer usage are available to the farmer and the horticultural grower. The farms and horticultural unit at Levington, the farm at North Wyke and the provincial service throughout Great Britain are available for carrying out experiments. In this way, research projects organized from Levington can be examined in a wide variety of the soils and climate found in British farming and horticulture.

In 1961 more than 20,000 plots constituting 648 agricultural and horticultural experiments are being laid down, over half being provincial, and the pot trials unit at Levington has an extensive complementary programme.

Subjects investigated can be described under two main headings, namely: General Agriculture and Specialized Grassland. Some of the more important subjects investigated are discussed below, but those relating to Horticulture are discussed under that section (page 35).

Full details of the 1961 experimental programmes are to be found at the end of this section.

General Agriculture

Nitrogen sources. A wide range of nitrogen sources, including ammonium sulphate, ammonium nitrate, calcium nitrate, urea, mono-ammonium phosphate and di-ammonium phosphate have been compared since 1956 in fifty experiments on grassland and fifty-seven on arable crops. No appreciable differences have been detected on roots or cereals but on grassland urea has tended to give a smaller crude protein and dry matter response than other sources.

No statistically significant interactions between nitrogen source and time of application have been apparent in individual experiments but in each of four experiments on all grass swards in 1958, the nitrogen recovery from calcium nitrate applied in autumn or early spring was less than that from ammonium sulphate and ammonium nitrate applied at the same time. After late spring applications, on the other hand, the nitrogen uptake from calcium nitrate was greater than that from the other test sources.

Both grassland and arable investigations will be continued in 1961, with greater attention being given to comparisons of nitrogen sources when combine drilled with cereals.

Agronomic Experiments

Nitrophosphates. From an examination of certain continental nitrophosphates in 1956, investigations on this subject have been expanded each year, with particular emphasis being placed on phosphate form.

In a number of experiments superphosphate has been used as a standard against which to test the agronomic value of dicalcium, tricalcium and octacalcium phosphate and hydroxyl apatite. Any of these may be present in commercial nitrophosphates together with ammonium phosphate compounds.

In three pot experiments there has been little difference between monocalcium phosphate and dicalcium phosphate dihydrate on a number of soil types in a pH range of 5·8–7·8. On occasion, however, the anhydrous form of dicalcium phosphate has given slightly lower yields of both dry matter and P_2O_5. Investigations on the immediate effects of the various calcium phosphates have shown that the more basic materials are generally less available to plants than the mono- and dicalcium phosphate forms. This was particularly the case in soils with a pH greater than 7·0. Where residual crops have been taken, however, there has often been no detectable superiority of mono- and dicalcium phosphates over the more basic calcium phosphates.

In four field experiments on soils with a pH below 7·0 in 1959, nitro-phosphates containing granular dicalcium phosphate or more basic granular forms were equivalent to superphosphate as sources of P_2O_5 for swedes. In four experiments on potatoes in 1958, the phosphate response decreased on average in proportion to the decrease in the proportion of water-soluble phosphate present. Nitrophosphates prepared by different processes have been compared in 1960 and work on this subject, together with investigations on the effect of particle size, are continuing in 1961.

Forms of Basic Slag. Investigations on this subject were started in pot experiments and in three field experiments on grassland in 1958. In 1959 the number of grassland experiments was increased to five and records are to be obtained in 1961 from one of these sites. Six new field experiments are being started in 1961.

The scope of the pot investigations has been extended each year and in 1960 a start was made on an experiment to measure in 1962 the crop response to basic slag after a two-year period of incorporation in soil.

No comprehensive statement can be made at this stage on results from the above experiments but there is evidence from the pot work to suggest that on acid soils at least, and where the basic slag is mixed throughout the soil, the importance of fineness of grinding may be less than has been supposed in the past. Top-dressing experiments in pots and on grassland are being continued in 1961.

Liquid Fertilizers. The application of plant nutrients in solution is sometimes held to reduce the time taken for response and in certain circumstances it may also be a

more convenient method of application. Experiments are being carried out in 1961 on a number of aspects connected with the use of liquid fertilizers. Among the subjects under investigation are nitrogen sources, the speed of the nutrient response and the practical significance of foliar scorch.

Barley – time of N application. Eighteen experiments carried out from 1957 to 1959 examined the effect of time of application of nitrogen to barley. Seedbed applications were compared with top dressing in May and in June and with various split-dressing treatments. The series was initiated to establish whether it is possible, by applying some or all of the nitrogen late in the growing season, to increase grain nitrogen content and feeding value without reducing to any important extent the effect of nitrogen on grain yield. From the results it is evident that, although the effect of time of application can vary very much from site to site, application of nitrogen in June often leads to marked reductions in grain yield compared with earlier applications, whereas gains in feeding value when they occur are usually small.

Potatoes – forms of potash. Twenty experiments have been carried out since 1956 to compare the effects of muriate and sulphate of potash on potato yield and quality and further work is being done in 1961. Muriate of potash has often given a higher yield of large tubers and lower yield of medium tubers than sulphate but, in general, total yield has been similar for the two sources. High rates of potash have reduced tuber dry matter in some cases and there has been a tendency for sulphate of potash to give a rather higher dry-matter content than muriate. A tasting panel scores samples from selected treatments for texture and flavour in these and certain other projects, and blackening of the cooked tuber is also assessed. No marked treatment effects have been detected.

Potatoes – NPK requirements. A series of annual experiments on typical soil types throughout the country examines four rates each of nitrogen, phosphate and potash on potatoes. Forty-seven experiments have been carried out between 1956 and 1960 and the series is being continued at a further five sites in 1961. A primary object of these experiments is to accumulate data in the long-term which can be averaged over regional and other grouping to provide a basis for economic interpretation. Correlation with soil analysis is an equally important long-term study.

Early potatoes – NPK and bulking rate. In 1960 NPK factorial experiments were laid down at three sites in south-west Scotland and in 1961 a further five sites, giving a wider coverage of the first early potato districts, are planned. In 1961 the potatoes will be harvested on three dates to give some information on rate of bulking as affected by fertilizer treatment. Complementary to these projects, a more complicated

experiment is being repeated at Levington in 1961 with fourteen lifting dates on both a first early and a main-crop potato variety.

Magnesium – arable crop requirements. In the Levington programme between 1954 and 1959, rates of magnesium of from 20 lb. to 80 lb. acre MgO were applied to potatoes in a total of nineteen experiments on sandy or loamy soils. A statistically significant increase in yield was recorded in six out of nineteen of these experiments on main crop potatoes with the average increase in yield over-all main-crop experiments being of the order of 0·5 to 0·75 ton/acre. In two out of five experiments on early potatoes, magnesium application led to a reduction in yield.

In 1960 this work was extended to cover sugarbeet and spring cereals in addition to potatoes and the relationship between potash application and magnesium deficiency was also examined; this investigation will continue in 1961.

Wheat bulb fly control. In the autumn of 1956 experiments were laid down to examine the effectiveness of Aldrin incorporated in superphosphate and in various inert carriers as control measures for wheat bulb fly. Interest lay not only in the direct effect of Aldrin but in the possibility that phosphate application would cause increased tillering and thus enable the crop to grow away from an attack. The first experiments examined Aldrin rates above 1 lb./acre but in subsequent years rates were reduced to a minimum of 0·3 lb./acre.

In all, twenty experiments have been carried out. Results indicate that the rate of Aldrin for effective control varies from 0·3 to at least 0·75 lb./acre. In some cases phosphate has increased tillering and, to some extent, resistance to wheat bulb fly attack.

Wild oat control by Tecane. For the seasons 1957–60 observational plots have been put down at over 200 sites on a wide range of crops and soils and supplemented by thirty-six fully replicated experiments and seven pot trials. In 1961 this subject of investigation will be concluded with residual observations of the 1960 experiments.

Specialized Grassland

This covers work relating specifically to grassland, its utilization and techniques associated with measurements of animal production. Where grass is used as a crop to measure basic differences between nutrient sources the work will be discussed under General Agriculture.

Pure grass swards – NPK responses. The response of pure grass stands to nitrogen, phosphate and potash has been measured in experiments where yields and chemical composition are estimated in successive cuts from ungrazed swards. Results have

shown that grass will respond to very high rates of nitrogen application and that responses in terms of nitrogen yield continue to be linear even after dry matter yields fall off. The response to nitrogen, in terms of dry matter production, has been shown to be limited not only by potash supplies but also by the absence of phosphate.

Further investigations into the effect of manuring grass are planned for 1961 and 1962. In these investigations the effect of the level of application of nitrogen, phosphorus and potassium on the digestibility of different herbage species will be examined.

Yield and composition – N/P relationships. The response of mixed swards to phosphate as superphosphate applied at different periods of the year with varying rates of nitrogen is being investigated. Early results do not show any clear effect of time of application on herbage yields, but suggest that responses to phosphate are, in some instances, enhanced by high rates of nitrogen application.

Yield and composition – N/K relationships. The effect of potash on mineral composition of spring grass when applied at different times of the year and associated with different levels of nitrogenous fertilizer, is being examined in a series of annual experiments. The long-term effects of various rates of nitrogen and potash applied to swards frequently cut for silage is considered in a separate series of experiments.

Mixed swards – N and management factors. Investigations have been conducted during 1959 and 1960 covering:

(a) the contribution of clover to the nitrogen and herbage yield of mixed swards,
(b) the effect of applied nitrogen on this contribution,
(c) the extent to which grazing animals modify this contribution,
(d) the effect of stage of defoliation upon the clover contribution.

Results so far obtained indicate that under North Wyke conditions clover plays a very considerable part in the dry matter production of mixed swards and in the provision of nitrogen to the sward. When this contribution is assessed in terms of bulk yield where no fertilizer is applied, it ranges from about 60 per cent increase when the sward is cut continuously to 110 per cent increase when the herbage is grazed. The increase in yield of total herbage is similar to that which would be obtained from the application of 100–120 lb. of fertilizer nitrogen applied to an all-grass sward.

There is also evidence that the application of fertilizer nitrogen to grazed mixed swards can produce increases in yield of total herbage without appreciable clover suppression and that, in fact, the amount of clover present is largely unaffected by the application of moderate levels of fertilizer nitrogen. Clover in a mixed sward can

be depressed very markedly by shading, and where grass growth is stimulated by nitrogen application the stage at which the sward is defoliated becomes more important.

In 1961 it is proposed to extend these investigations to Levington, where information can be gained on the clover contribution under contrasting soil and climatic conditions. At North Wyke the effect of phosphate on clover contribution will be investigated in a new project conducted under grazing management.

Trace elements – copper and molybdenum. In a series of observational experiments the effect of copper and molybdenum on upland pasture has been examined. So far no responses to trace elements have been reported, but at some centres the application of phosphate and lime has brought about marked improvement on general sward vigour and clover growth.

Magnesium uptake and Hypomagnesaemia. Investigations into the effects of magnesium application on herbage mineral composition have continued. Comparisons are being made between single large applications of calcined magnesite and annual small dressings of magnesite and kieserite. Increase in herbage magnesium content has been obtained from annual dressings of between 30–90 lb. of magnesium oxide but so far there have been no clear cut differences between the increases obtained from the different magnesium sources. In 1961 the investigations will be extended to examine the effect of season of application of magnesium on mineral composition of the herbage in spring.

Experiments examining the effect of fertilizers on herbage mineral composition, including magnesium levels and the effect of these magnesium levels on the incidence of hypomagnesaemia, have continued. Work so far has shown that clover has a much higher magnesium content than grass. When grass magnesium levels are low in April and May, the contribution from the clover is not sufficient to compensate fully for this. In a grazing experiment at Levington in 1960 MgO was applied at a high rate, known to be effective in raising herbage magnesium levels and at a very low rate which might be more acceptable in practice, if effective, and was compared with no applied magnesium. Herbage magnesium was raised substantially and was reflected in the blood serum magnesium levels of dairy cows at both rates of application. Further investigations are planned for 1961, using both dairy cows and sheep as test animals in grazing experiments. The effect of time of application of magnesium will also be studied in a series of experiments located at various provincial sites.

Experimental Techniques. Investigations of changeover designs in milk production studies have continued and so far it has been demonstrated that significant responses can be obtained to feed changes in indoor feeding experiments using a seven-day

changeover design. The development of changeover techniques for use in grazing studies will be investigated in 1961. Simultaneously, further work is investigating the degree of sensitivity of short period changeover designs with small differences in the quality of the treatment feeds.

A number of sampling machines have been compared on various sward types for their efficiency and ease of handling. It has been concluded that for large sample areas a motor scythe with a reciprocating knife is the best machine, and that for small areas the choice lies between a specially adapted sheep shearhead and a petrol-engined portable hedge trimmer, the former being most valuable for use for estimating animal intake as it will cut below grazing height.

EXPERIMENTAL PROGRAMMES

Key to Locations

Agriculture

L	Levington Research Station, Ipswich, Suffolk
W	North Wyke Experimental Station, North Tawton, Devon
1	Perth, North-East and South-East Scotland
2	Carlisle, North of England and South-West Scotland
3	Chester, West Midlands, North Wales and Lancashire
4	Bristol, South Wales, South Midlands and Southern Counties
5	South-Western Counties
6	Lincoln, East Midlands and Yorkshire
7	East Anglian and South-Eastern Counties

Horticulture

L	Levington Research Station, Ipswich, Suffolk
TP	Testing Panel
11	Levington Extension
12	Western Counties
13	Eastern Counties
14	Southern Counties
15	Lea Valley

Agricultural Experiments

Code No.	Title	Crop	Subject under investigation	Location
GENERAL AGRICULTURE				
1.1/1	N source and time	Winter wheat	Nitrogenous fertilizers for autumn application	3, 4, 7
1.1/2	N source, top dressing	Winter wheat	Nitrogenous fertilizers as spring top dressing	1, 2, 3, 4, 6, 7
1.1/3	N source, seedbed	Barley	Nitrogenous fertilizers for seedbed application	L, 5, 7
1.1/4	N source, rate and time	Grass	Time of application in relation to spring growth	3, 5, 6, 7
1.1/5	N source, seedbed	Sugar beet	Nitrogenous fertilizers for seedbed application	L, 4, 6, 7
1.1/6	N source, top dressing	Grassland	Nitrogenous fertilizers for intensive use on grassland	1, 2, 3, 7
1.1/7	N source, combine drilled	Winter wheat	Nitrogenous fertilizers for seedbed applications	L, 5
1.1/8	N source, top dressing	Winter wheat	Nitrogenous fertilizers as spring top dressing	1, 3, 7
1.1/9	N source, top dressing	Grass	Various nitrogenous fertilizers	1, 2, 3, 5, 7
1.1/10	N source, top dressing	Grass	Various nitrogenous fertilizers	1, 2, 3, 5, 7
1.1/11	N source, combine drilled	Barley	Nitrogenous fertilizers for combine drilling	1, 2, 3, 4, 5, 6
1.1/12	N source, rate, method and time	Mustard	Time of nitrogen fertilizer application	4, 6, 7
1.1/13	N rate and time	Maize	Rate and time of application to maize grown for silage	L, 4, 5

Code No.	Title	Crop	Subject under investigation	Location
1.1/14	N source	Potato	Nitrogenous fertilizers for potatoes	1, 2, 3, 4, 5, 6, 7
1.1/15	N source and method	Potato	Method of nitrogen application	L
1.2/1	P source	Grass	Granular nitrophosphate for grassland fertilization	1, 2, 3, 4
1.2/2	P rate and time	Lucerne	Residual effects of phosphate applied to established lucerne in 1960	7
1.2/2	P rate and time	Lucerne	Rate and time of application of phosphate to established lucerne	6, 7
1.2/3	P source, nitrophosphates	(a) Potato (b) Swede (c) Kale	Granular nitrophosphates for potatoes and brassica	1, 2, 3, 6, 7 1, 2, 3, 5 1, 2, 3, 5, 6, 7
1.2/4	P source nitrophosphates	(a) Potato (b) Swede	Granular nitrophosphates containing various forms of phosphate	1, 2, 3, 4, 5, 6 1, 2, 3, 4, 5
1.2/5	P source, nitrophosphates	(a) Swede (b) Potato	Residual effects of nitrophosphates applied in 1960	W, 2 L
1.2/5	P source, nitrophosphates	(a) Grass (b) Spring wheat	To measure in 1962 the residual effects of nitrophosphates applied in 1961	W L, 4
1.2/9	P rate and method, crop development	Winter wheat	Phosphate rate and method of application	L
1.2/10	P rate and source, crop development	Spring cereal	Crop development and final yield as influenced by phosphate application	1, 2, 3, 4, 5, 6, 7
1.2/11	P rate, source and method, crop development	Spring cereal	Crop development and final yield as influenced by phosphate and method of application	1, 2, 3, 7
1.3/1	K source	Early potato	Relative value of muriate and sulphate of potash	2, 3, 4, 5
1.3/2	K rate and time	Lucerne	Rate and time of potash application to established lucerne	6, 7
1.6/1	PK time	Winter wheat	Time of application of phosphate and potash	4, 6, 7
1.7/1	NPK rate	Potato	Nitrogen, phosphate and potash rates in relation to yield, disease control, potato quality and soil analyses	1, 2, 3, 5, 7
1.7/2	NPK rate	Early potato	Nitrogen, phosphate and potash rates for early potatoes	2, 3, 4, 5
1.7/3	NPK rate, bulking	Early potato	Nitrogen phosphate and potash rates in relation to rate of bulking	L
1.7/4	NPK rate	Kale	Response of kale to nitrogen, phosphate and potash	2, 4, 7
2.2/2	NKMg rate	Spring wheat or spring barley	Magnesium deficiency in relation to nitrogen and potash rate	1, 2, 3, 4, 5
2.2/3	KMg rate method	Barley	Methods of magnesium application in relation to potash rates and method of application	L, 7
2.2/4	KMg rate and Mg method	(a) Potato (b) Sugarbeet	Magnesium deficiency in relation to potash rates	1, 3, 6, 7 1, 3, 4, 7
2.2/9	Mg rate	Rotation	Additive effect of magnesium applications throughout a rotation	1
2.5/2	B source	Swede	Availability of boron from various sources when incorporated in fertilizer	1, 2
2.5/3	B rate	Lucerne	Use of boron on stands of lucerne	7

Code No.	Title	Crop	Subject under investigation	Location
2.8/1	Liquid fertilizer, N source	Winter wheat	Liquid nitrogenous fertilizers as a top dressing for winter wheat	L, 2, 6, 7
2.8/2	Liquid fertilizer (N source, scorch)	(a) Winter wheat (b) Barley	Possible scorch effects from liquid nitrogenous fertilizers	L L
2.8/3	Liquid fertilizer (N source, time and method)	Winter wheat	Method and time of top dressing application to winter wheat	L, 3, 6, 7
2.8/4	Liquid fertilizer (N time and method)	Barley	Method and time of top-dressing application to barley	L, 7
2.8/5	Liquid fertilizer (NPK rate and N source)	(a) Potato (b) Swede (c) Kale (d) Sugarbeet	Response of various crops to liquid and solid compound fertilizers	3, 4, 6, 7 1, 2 L, 7 L, 7
2.8/6	Liquid fertilizer (N source, yield)	Mixed sward	Effect of liquid nitrogenous fertilizers on the yield of a mixed sward	3, 6, 7
2.8/7	Liquid fertilizer (NPK rate and time)	Grassland	Response of grassland to liquid and solid compound fertilizers applied at different times	1, 2, 4, 5, 7
2.8/8	Liquid fertilizer (method and stage of growth)	Mixed sward	Possible scorch effects where liquid fertilizers are used on grassland	L
2.12/1	Particle size, phosphate fertilizer	(a) Potato (b) Swede	Particle size in relation to crop response to phosphate	1, 3, 4, 5, 6, 7 2, 3, 4, 5, 6
2.12/2	Type 'B' fertilizer	(a) Potato (b) Kale (c) Sugarbeet	Crop response to Type 'B' fertilizer	2, 4 3, 5 1, 4
2.12/3	Form of basic slag	Mixed sward	Response of grassland to different forms of slag	1, 2, 3, 4, 6
2.12/4	Type 'B' fertilizer	Grass	Response of grassland to Type 'B' fertilizer	1, 4
2.12/5	Form of basic slag	Mixed sward	Short and long-term response of grassland to basic slag	5
2.13/1	Compound fertilizer placement	Spring wheat or barley	Combine drilling of high rates of compound fertilizer	3, 4, 6, 7
2.13/2	'47' rate, combine drilling	Winter wheat	Combine drilling high rates of potash in a PK compound	L, 1, 2, 3, 4, 5, 6, 7
2.13/8	Compound fertilizer placement	Pea	Combine drilling of fertilizer for peas in 7-in. rows	L, 6, 7
2.13/9	Compound fertilizer, combine drilling	Kale	Combine drilling of fertilizer for kale	L
2.14/1	NPK exhaustion	Potato	Response to these nutrients after successive years of nitrogenous fertilization in rotations	L
2.20/1	N rate and time, anhydrous ammonia	Kale	Residual effects of anhydrous ammonia applied to kale in 1960	L, 7
2.20/1	N rate and time, anhydrous ammonia	Kale	Rate and time of application of anhydrous ammonia	L, 7
2.20/3	Anhydrous ammonia, N rate and time	Grass	The use of anhydrous ammonia on grassland	L
2.20/4	Anhydrous ammonia, top dressing	Winter wheat	Anhydrous ammonia as a top dressing	L, 7
2.20/5	Anhydrous ammonia	(a) Potato (b) Sugarbeet	Use of anhydrous ammonia for these crops	L L, 7

Code No.	Title	Crop	Subject under investigation	Location
2.20/6	N source and rate, anhydrous ammonia	Grass	Anhydrous ammonia in comparison with ammonium sulphate	L
3.2/1	P storage	Rotation	Availability of phosphate in a variety of important soil types following phosphate applications	L, W, 1, 2, 3, 4, 5, 6, 7
3.2/2	P storage	Rotation	Availability of phosphate in two soil types following phosphate applications	1
3.2/3	P rate and source	Rotation	Long-term phosphate requirements of soils with an initially high phosphate status	1, 3, 4, 5, 6, 7
3.7/1	NPK rate	Rotation	Place of phosphate and potash in obtaining maximum crop response to nitrogen	L
4.4/1	Sulphur requirement	Rotation	Sulphur requirement of crops over a long period	L
4.14/1	PK exhaustion	Rotations	Rotations that will best produce phosphate and potash responsiveness	L
4.14/2	K exhaustion	Rotation	Residual effect of potash applied to the annual experimental area at Levington	L
4.19/1	Herbicides and insecticides	Rotation	Long-term effects of herbicide and insecticide applications in a normal farm rotation	L
4.19/2	Urea, long-term effects	Rotation	Long-term effects of urea with various biuret contents	L
4.19/3	Urea, long-term effects	Grass	Long-term effects of urea with various biuret contents	L, W
6.14/2	Type 'B' fertilizer, combine drilled	Winter wheat	Combine drilling of Type 'B' fertilizer	L, W
8.7/4	Time of planting, blight	Potato	Time of planting and the incidence of blight	L
10.8/2	Tecane survey, residual effects	Various	Residual effects of Tecane incorporated in fertilizer for the control of wild oats in 1960	1, 2, 3, 4, 5, 6, 7
12.1/1	K rate and source, FYM rate, tuber quality	Potato	FYM and potash source in relation to tuber quality and yield	L
16.1/1	Sampling technique	Kale	Optimum sampling procedure for estimating yield of kale	L
16.1/3	Sampling variability	Sugarbeet tops	Variability of dry matter and nitrogen content	L, 4, 6, 7
16.1/4	Sampling variability, sheaves	Cereals	Variability of grain content in hand-gathered sheaves cut by Allen scythe	All
16.5/1	Plot size	Swedes or Sugarbeet	Statistical examination of the results from various plot sizes	L, 1, 2, 3, 4, 5, 6, 7
16.6/1	Harvesting technique	Cereals	Harvesting methods for cereal plots	L
16.6/2	Combine harvester grain carryover	Cereals	Carryover of grain from plot to plot	L

Code No.	Title	Crop	Subject under investigation	Location
SPECIALIZED GRASSLAND				
1.1/1	N rate, cutting frequency and clover contribution (1)	Grassland	Nitrogen contribution from clover in relation to applied nitrogen and frequency of cutting	W
1.1/2	N rate, cutting frequency and clover contribution (2)	Grassland	Nitrogen contribution from clover in relation to applied nitrogen and frequency of cutting	W, L
1.1/6	N rate, clover contribution	Grassland	Nitrogen contribution from clover under grazing conditions	W
1.2/1	Basic slag, acid soils	Grassland	Various types of basic slag	1
1.2/7	P source and time, calcareous soils	Grassland	Sources of phosphate in relation to sward composition and yield	4, 5
1.2/8	P source and time, acid soils	Grassland	Sources of phosphate in relation to sward composition and yield	2, 5, 6
1.4/1	NP rate and P time	Grassland	Time and rate of phosphate application in relation to nitrogen rate	3, 5, 6
1.4/2	NP rate and clover contribution	Grassland	Effect of nitrogen and phosphate on the yield and composition of grazed swards with and without clover	W
1.5/1	NK rate and K time	Grassland	Time and rate of potash application in relation to nitrogen rate	3, 7
1.5/2	NK rate and K time, herbage composition	Grassland	Nitrogen and potash rate and potash time in relation to chemical composition of spring herbage	1, 3, 5, 6, 7
1.6/1	PK rate	Mixed sward	Potash and phosphate in relation to herbage production under cow grazing	W
1.6/2	PK time, early bite	Grassland	Time of phosphate and potash application for the production of early bite	4, 5
1.7/4	NPK rate, hay	Grassland	Nitrogen, phosphate and potash rates in relation to yield and sward composition	1
2.2/1	Mg rate and time, fertilizer incorporation	Mixed sward	Residual and cumulative effects on the magnesium content of spring grass of two sources of magnesium applied at various times	2, 3, 4, 5, 6
2.3/1	Na Mg K rates, herbage composition	Grass	Influence of sodium on herbage magnesium levels	L
2.5/1	Marginal land development	Grassland	Effect of a variety of nutrients on productivity	1, 5
2.5/2	Micronutrients and clover growth	Mixed sward	Effect of important micronutrients on clover growth	W
2.5/7	Hill land development	Grassland	Effect of a variety of nutrients on productivity	3
2.13/7	Sub-surface fertilizer applications	Mixed sward	Deep placement of nitrogen, phosphate and potash on an established sward	W
4.2/1	Cumulative Mg top dressing	Grassland	Long-term effect of repetitive small applications of magnesium on magnesium content of herbage	1, 2, 4, 5

Code No.	Title	Crop (or animal)	Subject under investigation	Location
6.2/1	Culm measure drainage	Grassland	Most suitable method of drainage on culm measure soils	W
6.7/1	NPK rate	Grass species	Nitrogen, phosphate and potash requirements of individual grass species	W
7.2/2	Mg rate, hypomagnesaemia, dairy cows	Grass	Magnesium applications to grassland in relation to animal health	L
7.2/3	Mg rate, hypomagnesaemia, sheep	Grass	Magnesium applications to grassland in relation to animal health	L
7.3/1	NPK rate, digestibility	Grass species	Nitrogen, phosphate and potash in relation to the digestibility of individual grass species	W
10.2/3	Buttercup control, pasture productivity	Grassland	Effect on herbage productivity of buttercup control with MCPA	5
10.4/5	Herbicide, fertilizer, weed control	Grassland	Residual effects on weed control of herbicide incorporated in fertilizer applied in 1960	1, 2, 3, 4, 5, 6, 7
16.1/1	Sampling methods, small grazed plots	Mixed sward	Variability associated with various grass sampling machines	W
16.8/1	Simulated grazing techniques	Grassland	Effect on productivity of various techniques used when plots cannot be grazed	W
16.8/2	Artificial return of nutrients	Mixed sward	Various methods for the return of nutrients to simulate grazing	W
16.10/1	Interrupted changeover technique, dairy cows	Mixed sward	An interrupted changeover technique, using dairy cows at pasture	W
16.10/2	14-day changeover, milk production	Dairy cows	Use of a 14-day changeover technique	W
16.10/3	14-day changeover, milk production	Milking goats	Use of a 14-day changeover technique	W
16.10/5	Changes in herbage digestibility	Grass	Change in digestibility associated with stage of maturity	W
16.10/6	Changes in herbage digestibility, milk production	Grass	Influence of a change in digestibility on the production of dairy cows	W
16.10/7	Changeover techniques in milk production trials	Dairy cows	Dairy herd records to investigate various types of changeover design	W
16.11/1	Establishment and management technique	White clover	Establishment and maintenance of pure white clover swards	W
16.11/2	N effect of sprayed out clover	Grassland	Effect of killing clover in an established sward by use of herbicide	W
16.11/3	N effect of sprayed out clover	Grassland	Effect of spraying out clover in its seeding and first harvest year	W
16.12/1	Systems of experimental management	Grassland	Importance of transference of fertility in grazed experiments	W

Horticultural Experiments

FRUIT

Code No.	Title	Crop	Subject under investigation	Location
1.4/2	N and P source and Mg rate	Blackcurrant	Organic and inorganic sources of nitrogen and phosphate, and rate of applied magnesium and trace element	L
1.7/2	NPK rates and time of application	Blackcurrant	Fertilizer rates and time of application in relation to flowering, fruiting, disease incidence and tissue composition	L
1.7/3	NPK rates and time of application	Strawberry	Fertilizer rates and time of application in relation to flowering, fruiting, disease incidence and tissue composition	L
2.9/1	Chelated iron and correction of foliar chlorosis	Dessert apple Pear	Correction of foliar chlorosis by foliar and soil applications of chelated iron	12 13 14
2.11/1	Urea sprays	Dessert apple	Growth and phytotoxicity from foliar sprays of urea	L
2.14/1	Nutrient exhaustion	Blackcurrant	Specific nutrient deficiency levels	L
2.14/2	Nutrient exhaustion	Culinary apple	Specific nutrient deficiency levels	L
2.14/3	Nutrient exhaustion	Dessert apple	Specific nutrient deficiency levels	L
2.14/4	Nutrient exhaustion	Pear	Specific nutrient deficiency levels	L
5.5/1	Mulching and N requirement	Blackcurrant	Rate of application of nitrogen with and without straw mulch	L
5.5/2	Mulching and N requirement	Blackcurrant	Rate of application of nitrogen with and without straw mulch	L
6.6/2	Establishment	Dessert apple	Method of establishment	L
6.6/3	Establishment	Pear	Method of establishment	L
10.2/1	Herbicides and phytotoxicity	Blackcurrant	Degree of weed control and phytotoxicity	L
10.2/3	Herbicides and phytotoxicity	Blackcurrant	Degree of weed control and phytotoxicity	L
10.2/4	Herbicides and phytotoxicity	Blackcurrant	Degree of weed control and phytotoxicity	L
10.2/5	Herbicides and phytotoxicity	Blackcurrant Gooseberry Raspberry Redcurrant	Degree of weed control and phytotoxicity	L
10.2/6	Herbicides and phytotoxicity	Pear	Degree of weed control and phytotoxicity	L
10.2/7	Herbicides and phytotoxicity	Dessert apple	Degree of weed control and phytotoxicity	L
10.10/1	Runner inhibition	Strawberry	Chemical inhibition of runner formation	L
10.10/2	Runner inhibition	Strawberry	Chemical inhibition of runner formation	L
10.10/3	Runner inhibition	Strawberry	Chemical inhibition of runner formation	L
10.10/4	Runner inhibition	Strawberry	Chemical inhibition of runner formation	14
10.10/5	Runner inhibition	Strawberry	Chemical inhibition of runner formation	L

Code No.	Title	Crop	Subject under investigation	Location
GLASSHOUSE CROPS				
1.1/1	Nitrogen source	Tomato	Organic and inorganic sources of nitrogen	L
1.1/2	Nitrogen source	Cucumber	Organic and inorganic sources of nitrogen	L
1.1/4	Nitrogen source	Tomato	Organic sources of nitrogen	L
1.5/1	NK requirements	Carnation	Related nitrogen and potash requirements	L
1.7/1	NPK nutrition	Tomato	Related nitrogen, phosphate and potash nutrition	L
2.6/1	pC values	Tomato	Effect on growth of low pC values	L
2.8/1	Liquid feeding	Tomato	Methods of liquid feeding compared with solid feeding	L
2.8/2	Liquid feeding	Carnation	Methods of liquid feeding compared with solid feeding	L
2.8/3	Liquid feeding	Tomato	Rates and methods of liquid feeding	L
2.8/4	Liquid feeding	Tomato	Methods of liquid feeding compared with solid feeding	L
2.8/5	Liquid fertilizer	Pot plants	Methods and rates of application	L
2.9/1	Foliar chlorosis	Hydrangea	Soil and foliar applications of chelated iron for the correction of chlorosis	L
5.3/1	Peat type in rooting medium	Helianthemum	Effect of various peats in a rooting medium for cuttings	L
5.3/2	Peat type as soil improver	Tomato	Effect of various peats as soil improvers	14 15
5.3/4	Peat type as soil improver	Tomato	Effect of various peats in a compost	L
9.7/1	General purpose insecticide	Pot plants	Phytotoxicity	L
VEGETABLES, FLOWERS, ETC.				
1.5/1	NK requirements	Brussels sprouts	Related nitrogen and potash requirements	L
2.8/1	Liquid fertilizers	(a) Vegetables (b) Flowers	Methods of applying liquid fertilizers	L
2.9/1	Iron nutrition	(a) Vegetables (b) Flowers	Influence of chelated iron on growth and cropping	L
2.9/2	Iron nutrition and phytotoxicity	Vegetables	Effect of chelated iron on growth and phytotoxicity	L
2.9/3	Iron nutrition	Rose	Influence of chelated iron on growth and cropping	L
2.9/4	Iron nutrition	Rose	Correction of lime induced chlorosis by chelated iron	14
2.11/1	Irrigation and nutrition	Lettuce	Inclusion of fertilizer in irrigation water	L
3.7/1	NPK nutrition	Vegetables	Related NPK requirements	L
5.3/1	Peat type as a soil improver	Lettuce	Peat types as soil improvers	L
6.13/1	Cut flower longevity	Flowers	Flower preservatives	L
6.13/2	Cut flower longevity	Flowers	Flower preservatives	TP

Horticultural Experiments

Code No.	Title	Crop	Subject under investigation	Location
9.7/1	General purpose insecticide	(a) Vegetables (b) Flowers	Phytotoxicity	L
9.8/1	Combined insecticide/ fungicide	Rose	Pest and disease control	L
10.2/1	Herbicide and phytotoxicity	Onion	Degree of weed control and phytotoxicity	L
10.2/2	Herbicide and hormone weed killers, total weed control	—	Total weed control with combinations of herbicides	L
10.2/3	Herbicide and phytotoxicity	Asparagus	Degree of weed control and phytotoxicity	L
10.10/1	Growth inhibition	Privet	Phytotoxic effects of a growth inhibitor	11
10.10/2	Growth inhibition	(a) Privet (b) Hawthorn	Growth inhibition in relation to concentration and method of application	11 L
10.10/3	Growth inhibition	Hedge types	Growth inhibition and phytotoxicity when applied annually to a range of hedge types	TP
10.10/4	Growth inhibition	(a) Privet (b) Hawthorn	Growth inhibition at various times of application	11 L
10.10/5	Growth inhibition	(a) Privet (b) Hawthorn	Growth inhibition at various rates of application	11 L
10.10/6	Growth inhibition	Hedge types	Growth inhibition when applied with a hand syringe	L 11
FINE TURF				
1.1/1	N source	Turf	Ureaformaldehyde in spring and summer fertilizers	L
1.1/2	N source and rate	Turf	Long-term effect of nitrogen source and rate on growth, botanical composition and disease incidence	L
1.1/3	N source and rate	Turf	Long-term effect of nitrogen source and rate on growth, botanical composition and disease incidence	L
1.2/1	P source and rate	Turf	Long-term effect of phosphate source and rate on growth, botanical composition and disease incidence	L
1.6/1	PK rate and time	Turf	Long-term effect of P and K on growth, botanical composition and disease incidence	L
1.7/1	Fertilizer formulations	Turf	Effect of various fertilizer formulations on growth, botanical composition and disease incidence	L
1.7/2	NPK nutrition	Turf	Effect of fertilizer on sward composition	L
2.8/1	Liquid fertilizer	Turf	Types and methods of applying liquid fertilizers	L
2.8/2	Liquid potash fertilizer	Turf	Sources of potash fertilizer applied as a liquid	L
2.9/1	Improvement of growth and colour	Turf	Improvement of growth and colour by chelated iron	L
9.1/1	Worm killer	Turf	Various worm killers	L

Code No.	Title	Crop	Subject under investigation	Location
10.1/1	Copperas in lawn fertilizer	Turf	Value of copperas in lawn fertilizer	L
10.1/2	Herbicides	Turf	Selective herbicide in an established sward	L
10.1/3	Herbicides	Turf	Selective herbicide in a seed bed	L
10.1/4	Herbicides	Turf	Selective herbicide in an established sward	L
10.2/1	Herbicides	Turf	Types of herbicide in relation to clover control	L
10.2/2	Herbicides	Turf	Pre-sowing selective herbicide application and sward establishment	L
10.2/3	Herbicides	Turf	Aerosols in relation to spot killing of weeds	L
10.2/4	Herbicides	(a) Turf (b) Lettuce	Composting of grass mowings taken from swards treated with selective herbicides	L
10.2/5	Herbicides	Turf	Comparisons of selective herbicides	L 11
10.2/6	Herbicides	Turf	Pearlwort control by selective herbicides	11
10.2/7	Herbicides	Turf	Selective herbicides	TP
10.2/8	Herbicides	Turf	Methods of applying selective herbicides	L
10.2/9	Herbicide and growth inhibitor combined	Turf	Effect of a combined herbicide and growth inhibitor	L
10.2/10	Herbicides	Turf	Effect of time of application on selective herbicides	11
10.4/1	Combined herbicide and fertilizer	Turf	Degree of weed control afforded by herbicide/fertilizer combinations	L 11
10.4/2	Combined herbicide and fertilizer	Turf	Degree of weed control afforded by herbicide/fertilizer combinations	L 11
10.4/3	Combined herbicide and liquid fertilizer	Turf	Degree of weed control afforded by herbicide/liquid fertilizer combinations	L 11
10.4/4	Combined herbicide and soluble fertilizer	Turf	Degree of weed control afforded by herbicide/soluble powder fertilizer mixtures	L 11
10.10/1	Maleic hydrazide rates of application	Turf	Various rates of maleic hydrazide formulations upon inhibition of growth	L
10.11/1	Moss eradication liquid herbicides	Turf	Effect of combining chemicals and various herbicides upon moss and weed control	L 11
10.11/2	Moss eradication, liquid herbicides	Turf	Effect of combining chemicals and various herbicides upon moss and weed control	11
10.11/3	Moss eradication powder fertilizers	Turf	Effect of combining chemicals in a powder fertilizer upon moss control	L 11
10.11/4	Moss eradication, liquid herbicides	Turf	Effect of combining chemicals and various herbicides upon moss and weed control	L 11
10.11/5	Moss eradication	Turf	Effect of repetitive applications of various moss eradicants	L 11

Code No.	Title	Crop	Subject under investigation	Location
10.11/6	Moss eradication, powder fertilizer	Turf	Effect of combining chemicals in a powder fertilizer upon moss control	L 11
10.11/7	Moss eradication, liquid herbicides	Turf	Effect of combining chemicals and various herbicides upon moss and weed control	L 11

Pot Experiments

AGRONOMIC PROJECTS

1.1/1	Nitrogen source	Fine grass	Effectiveness of various nitrogenous fertilizers on the growth of fine grass
1.2/1	Phosphate nutrition	Lettuce	Residual effect of phosphate treatments
1.2/2	Phosphate source, calcium phosphates	Barley	Various water soluble and water insoluble phosphates
1.2/3	Phosphate source, nitro-phosphates	Mustard	Various water soluble and water insoluble phosphate ratios in fertilizers on different soils
1.2/4	Phosphate source, particle size	Mustard	Effectiveness of various phosphate fertilizers when ground to different degrees of fineness
1.2/5	Phosphate source, particle size	Ryegrass	Effectiveness of various basic forms of phosphate when ground to different degrees of fineness
1.2/6	Phosphate source, rock phosphates	Ryegrass	Effectiveness of different phosphate rocks when ground to various particle sizes
1.2/7	Phosphate availability, granular, powder	Ryegrass	Rate of P_2O_5 uptake from powdered and granular fertilizers
1.2/8	Phosphate availability	Ryegrass	Rate of P_2O_5 uptake from various water soluble phosphate fertilizers
1.2/9	Phosphate availability, compound fertilizers	Ryegrass	Availability of P_2O_5 from standard NPK and type 'B' compounds
1.2/10	Phosphate availability, magnesium	Ryegrass Mustard	Effectiveness of compound fertilizers stabilized with magnesium
1.7/1	NPK nutrition	Mustard	Correlation of crop response and soil analysis, British soils
2.5/1	Boron nutrition	Sunflower	Boron availability in compound fertilizers
2.19/1	Fertilizer toxicity	Barley	Possible toxicity from liquid fertilizers
2.19/2	Biuret in pelleted urea	Wheat	Possible toxicity from pelleted urea
2.19/3	Trace element toxicity	Oats	Possible toxicity from chromium
2.19/4	Triuret toxicity	Oats Wheat	Possible toxicity from triuret
2.19/5	Ureaformaldehyde toxicity	Tomato	Phytotoxicity from heavy dressings of ureaformaldehyde
2.22/1	Silicate mixtures	Tomato	Effectiveness of various silicate mixtures on plant growth
16.9/1	Technique	Mustard	Effectiveness of additional illumination in glasshouses
16.9/2	Technique	Mustard	Uniformity of plant growth in glasshouses
16.9/3	Technique	Mustard	Comparison of pot types and techniques
16.9/4	Technique	Various	Experimental variability associated with crops grown in pots
16.9/5	Technique	Various	Effectiveness of various fungicidal seed dressings

Code No.	Title	Crop	Subject under investigation
FUNDAMENTAL RESEARCH PROJECTS			
53.4/4	L value of soils from NPK nutrition of tomato experiment G.1.7/1(57)	Ryegrass	To determine the effect of cumulative phosphate treatments in a glasshouse experiment on the L-value of the soils
85.1/3	N form and rate, base dressing	Maize	Response of maize to various forms of nitrogenous fertilizers applied at 2 rates
85.1/6	N source and rate, soil, clay and organic matter	Maize	Influence of soil clay and organic matter content on the response of maize to various nitrogenous fertilizers
85.1/10	N source and rate, date of sowing	Maize	Effectiveness of various nitrogenous fertilizers applied at various times before sowing
85.1/12	N source and rate, top dressing	Various	Response of various crops to top dressing applications of three sources of nitrogen
85.1/20	N source and rate, biuret	Maize	Effect of biuret content on maize
85.1/21	N source and rate, various soils	Maize	Various nitrogen sources applied at different rates to various soils
85.1/22	N source, time of application	Maize	Influence of time of N application and the response of maize to two nitrogenous fertilizers
85.1/23	N rate and source, top dressing	Maize	Effect of top dressing and soil application on the response of maize to two nitrogen sources
85.1/24	N source rate and time of application	Maize	Influence of rate and time of application of nitrogen on the response of maize on five soils
81.8/1	N source, with P applications, basedressing	Maize	Influence of P rate on the response of maize to two nitrogen sources
81.9/1	N source, with P and K application, basedressing	Maize	Influence of P rate and K rate on the response of maize to two nitrogen sources
85.1/4	N source and rate, upward movement of soil water	Maize	Influence of the upward movement of water in soil on the response of maize to nitrogen
85.1/5	N source and rate, method of placement, various soils	Maize	Response of maize to three sources of nitrogen, applied at various rates in three ways in three soil types
85.1/7	N source and rate, soil water status	Maize	Influence of various soil water conditions on the response of maize to three nitrogen sources
85.1/8	N source and rate degree of leaching	Maize	Effects of various leaching treatments on the response of maize to three nitrogen sources
85.1/9	N source and rate soil pH	Maize	Influence of soil pH on the response of maize to applied nitrogen
85.1/13	N form and rate, top dressing	Maize Ryegrass	Response of maize and ryegrass to top dressing applications of nitrogenous fertilizers
85.1/14	N source and rate, top dressing watering conditions after top dressing	Maize	Influence of various watering treatments following top dressing applications of nitrogenous fertilizers
85.1/15	N source effect of temperature	Maize	Influence of two temperatures following the application of nitrogen on the subsequent response of maize
85.1/16	N source and rate effect of temperature	Maize	Influence of temperature following the application of nitrogen at three rates on the subsequent response of maize
85.1/17	N source and rate, temperature and soil water content	Maize	Influence of two temperatures and three soil water contents following the addition of three nitrogen sources at different rates on the response of maize

Experimental Locations

Code No.	Title	Crop	Subject under investigation
	L-value of soils from field experiment 1.2/4 (58)	Ryegrass	To determine the residual availability of phosphate applied to this experiment in 1958
	Phosphate response, reference soils	Ryegrass	To establish P response data for Soil Chemistry Reference Soils
	Trace element nutrition	Tomato	To examine the effect of certain trace elements in the nutrition of tomato
101.1/2	Effect of phosphorus, leaf area and growth of sugarbeet	Sugarbeet	To examine the effect of phosphorus supply on the total growth of sugarbeet

The field experiments in the provinces are planned at Levington for general agriculture and at North Wyke for specialized grassland, all being co-ordinated at Levington.

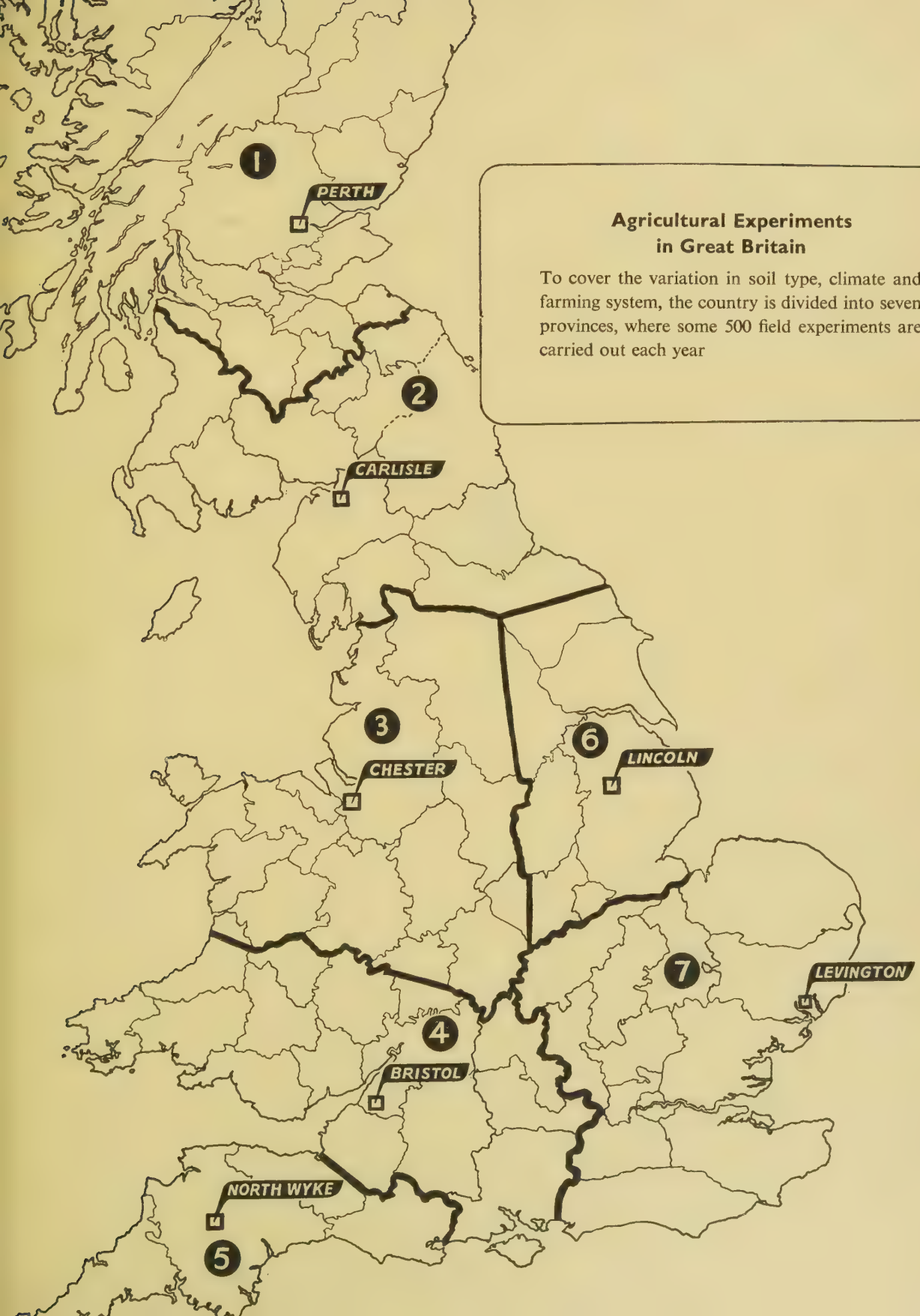
These experiments are carried out by the following Agricultural Advisers assisted by Crop Recorders, each Adviser being responsible for one of the locations into which the country is divided. In East Anglia, the South-Eastern and South-Western counties, the provincial work is done by Field Officers working either from Levington or from North Wyke.

Location			
1	Perth	J. M. Coull, Fisons Fertilizers Limited, Shore Road, Friarton, Perth.	*Perth 2384/5*
2	Carlisle	W. K. Letheren, The Poplars, Houghton, Carlisle, Cumberland.	*Carlisle 23155*
3	Chester	I. R. English, Field House, Okell's Lane, Cuddington, Northwich, Cheshire.	*Sandiway 2162*
4	Bristol	J. D. Edward, Fisons Fertilizers Limited, 11/19 Wine Street, Bristol.	*Bristol 2719/4*
5	South West	D. W. T. Brough, North Wyke Experimental Station, North Tawton, Devon.	*North Tawton 282*
6	Lincoln	W. A. G. Mason, Fisons Fertilizers Limited, Carholme Road, Lincoln.	*Lincoln 27421*
7	East Anglia, South East	A. M. Ainsley, F. W. Dunnett, Levington Research Station, Levington, Ipswich, Suffolk.	*Ipswich 76911*

Field experiments on horticultural crops are occasionally carried out in the provinces, but the majority are sited at Levington or in East Anglia (Location 13).

The Horticultural Advisers located in the provinces are:

Location			
12	Western Counties	C. P. Quarrell, Magnolia Cottage, 15 Charles Way, Malvern, Worcs.	
14	Southern Counties	J. C. Bush, 12 St. Matthew's Road, Weeke, Winchester, Hants.	*Winchester 3171*
15	Lea Valley	C. Evans, 'St. Davids', Falconers Park, Sawbridgeworth, Herts.	*Sawbridgeworth 3293*



Agricultural Experiments in Great Britain

To cover the variation in soil type, climate and farming system, the country is divided into seven provinces, where some 500 field experiments are carried out each year

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